40th Annual Armament Systems: Guns - Ammunition - Rockets - Missiles
Conference & Exhibition
"Translating Lessons Learned into Systems Requirements"

25 -28 April 2005

Agenda

Tuesday, 26 April 2005

General Session:

- Weapons Systems and Explosives Safety in a Joint Warfighting Environment, Mr. David C. Schulte, Executive Director, Naval Ordance Safety & Security Activity
- The Future of Small Missiles, Dr. James C. Bradas, Associate Director for Missile Technology, AMERDEC

Session: Modeling & Simulation

- Accuracy Modeling of the 120mm M256 Gun as a Function Of Bore Centerline Profile, Mr. David Smith for Dr. Ronald Gast, Benet Laboratories
- Opening New "DOORS" to Managing JSF Gun System Requirements, Ms. Renee I. Bellack, General Dynamics Armament and Technical Products
- Optimized Trajectory Shaping Guidance for an Air-to-Ground Missile Launched from a Gunship, Mr. Shane Sorenson, Naval Surface Warfare Center
- Estimating Ballistic Limits of Skin and Clothing for Projectiles, Mr. Henry E. Hudgins, US Army ARDEC
- A Review of The Insensitive Munitions Design Technology Workshop, Mr. M. Pascal Marchandin, NATO-MSIAC

Luncheon:

- Super Weapons – An Analysis, LTC Simon R. West, British Army, United Kingdom Defence Academy

Session: Medium Caliber System

- Oerlikon Ammunition for New Defense Environment, Mr. Allan N. Buckley, BTECH Oerlikon Contraves Pyrotec AG
- Multi Mission Vehicle Armament & Air Burst Munition for Expeditionary Warfare Force Protection, Mr. Andrew Bradick, Lockheed Martin
- 25mm Gun Systems for theF-35 Joint Strike Fighter (JSF), Mr. Douglass C. Parker, General Dynamics Armament and Technical Products
- Optimized Gun Barrel Targeting Investigation, Mr. Jeff A. Siewart, Arrow Tech Association
- Mk 110 Mod 0 / 57mm Naval Gun & Ammunition Certification Process, LT Timothy J. Hackett, USCG, US Coast Guard Deepwater Sponsors' Representative
- GAU-19/A Barrel Life Study, Mr. James J. St. Germain, General Dynamics Armament & Technology Products
- RNLA IFV Firepower: 30 mm versus 35 mm - 35 mm KETF Firing doctriney, Mr. Eelko van Meerten, TNO Defence, Safety & Security
- OMk44 Gun/Ammo IPT, Maj Kirk D. Mullins, USMC, DRPM AAA
- O30mm Airburst Development - Translating Lessons Learned into System Requirements, Mr. Paul A. Reynolds, General Dynamics - OTS

Wednesday, 27 April 2005

General Session:

- ATEC Update, BG(P) James R. Myles, USA, Commanding General, US Army Test & Evaluation Command
- Raytheon Missile Systems: A Global Perspective, Mr. Robert Salyer, Director, Business Development Raytheon Missile Systems
- Acquisition and Sustainment Program, COL Lloyd E. McDaniels, USA, Project Manager, CCWS Project Office

Session: Weapon Systems

- Weapon System Concepts for a Future Gunship, Mr. Michael M. Canaday, Naval Surface Warfare Center
- Royal Navy Small Calibre Gun Research to Defeat the Small Boat Threat, Mr. Johnathan Watkins, Defence Scientific Technology Laboratory
- Mini-Typhoon Remote Operated Small Arms Mount (ROSAM), Mr. Benjamin J. Hardie, General Dynamics Armament and Technical Products
- Update on Picatinny High Speed Turret, Mr. Mr. Richard Ciekurs, US Army RDECOM-ARDEC
- 40mm CTWS Supporting UK and France, Mr. Michael Duckworth, CTA International

Session: Missles & Rockets

Abraham Overview, Mr. Robert Daunfeldt, Bofors Defence
- Summary Overview of an Advanced 2.75 Hypervelocity Weapon, Mr. Larry Bradford, CAT Flight Services, Inc
- APKWS Flight Test Results, Mr. Larry Ingram and Mr. Dean Slocum, General Dynamics Armament & Technology Products
- APKWS Block II Demonstration Program , Mr. Milton E. (Gene) Henderson, Jr., US Army RDECOM-AMRDEC
- Missile Systems Lethality Enhancement Through the Use of a Conducting Aerosol Plasma Warhead, Mr. Allen H. Stults, US Army RDECOM-AMRDEC
- Next Generation Adaptable RF Seekers for Precision Munitions, Dr. Cory Myers, BAE Systems IEWS
- Technology for the Smart Rocket Launcher: The System Enabler For The 21st Century, Mr. Donald E. Davis, US Research, Development & Engineering Command
- Development of a Unique Penetrator Warhead for Rocket or Missile Delivery, Mr. Roger W. Melin, Lockheed Martin Missiles and Fire Control

Session: Large Caliber

- Development of the M1028, 120mm Anti-Personnel Tank Round, Mr. Hugh MacMillan, US Army Armaments Research, Development & Engineering Center and Mr. Neal Hylton, General Dynamics – Ordnance and Tactical Systems
- Metallic Materials & Processes Enabling Lightweight System Initiatives, Mr. Jeff Lehner, Director, Military Programs, Alcoa/Howmet Corporation
- Advanced Modular Gun Demonstrator: Redefining – "Faster Than A Speeding Bullet", Mr. Steve Coladonato, Applied Ordnance Technology, Inc.
- The Modified Tank Ammunition IMI M152/6 HEAT-AP- T, Mr. Danny Schirding, Chief Systems Engineer Tank Ammunition Directorate - IMI Ammunition Group
- A105/120/125 mm PELE Firing Results, Dr. Lutz Börngen, Rheinmetall Wafe Munition
- Line Of Sight/Beyond Line Of Sight (LOS/BLOS) Advanced Technology Demonstrator (ATD), Mr. David C. Smith, P.E., USA Benet Laboratories

Session: Energetics

- Development, Evaluation and Lifetime Prediction of Medium and Large Caliber Ammunition, Mr. Gert Scholtes, TNO
- Concepts and Practices in Finding and Applying Lessons Learned, Mr. David F. Fair, US Army ARDEC
- Propellant Replacement for the 105-mm M67 Propelling Charge, Ms. Adriana L. Eng, US Army ARDEC
- Lead Azide Replacement Program, Mr. John M. Hirlinger, US Army RDECOM-ARDEC
- Modeling Efforts for Autorotation Delivery System Concept Development, Mr. David C. Rutledge, Ph.D., Staff Engineer, United Defense

Thursday, 28 April 2005

General Session:

- Direct Fire Ammunition Lessons Learned: "More Than Just Impacts on Bullets", COL Mark Rider, USA, Project Manager, Maneuver Ammunition Systems
- U.S. Army ARDEC Overview & Special Weapon Observation Reconnaissance Direct-Action System (SWORDS), Mr. Anthony Sebasto, Associate Director for Technology & Business Development, AETC
- National Defense Industrial Association (NDIA) Armament Division - 2005 Division Status, Mr. Dave Broden, Chairman, Armaments Division, NDIA

Session: Technology & Manufacture

- Automated Ammunition Identification, Mr. David F. Pouliot, United Defense L. P.
- Design for Manufacturing & Assembly (DFMA), Mr. Steve Watts, US Army RD&E Command
- ARDEC Business Development Process, Mr. David L. Burkhardt, Director, Strategic Communications, US Army ARDEC
- MEMS IMU – Common Guidance, Dr. Vicki C. LeFevre, US Army RDECOM-AMRDEC and Mr. David W. Panhorst US Army ARDEC, US Army ARDEC
- Development and Testing of High Explosive (HE) Projectiles for Electro-Magnetic Gun Army Tech Objective (ATO), Mr. Manfredi Luciano, US Army ARDEC
- Metal Injection Molding of Wing/Flaperon, Mr. Jerry C. LaSalle, Director of MIM Operations, Polymer Technologies, Inc (PTI)
- TBX Evaluation Testing in the M151 (2.75") Warhead as Risk Reduction for the APKWS, Mr. Jason C. Gilliam, US Army RDECOM-AMRDEC
- Archer Artillery Program, Mr. Ulf Einefors, Bofors Defence
- Improvements to Airborne Ladar Man-in-the-Loop Operations, Mrs. Sarah J. Hard, RDECOM-AMRDEC

Session: Mortars & Artillery

- M865 TID Improvement Study, Mr. Jason W. Gaines, General Dynamics
- Lessons Learned from the Development of the U.S. Navy 5-Inch Force Protection Projectiles, Mr. Sanford (Luke) Steelman, III, Naval Surface Warfare Center
- Advanced Gun Barrel Technologies, Dr. Amir Chaboki and Mr. Allen Boutz, United Defense
- Defining Homogeneity for Medium Caliber Ammunition and Small Grain Propellant Lots, Mr. Scott Carney, ATK
- Precision Fires for the Field Artillery, Mr. John Halvey, Raytheon, and Stefan Blomgren, Bofors Defence
- Low Cost Course Correction (LCCC) Demonstration Program, Mr. George Barnych and Mr. Daniel Davis, Ordance and Tactical Systems Division
- XM395 Precision Guided Mortar Munition (120mm PGMM): Responsive, Standoff Precision Lethality for Highly Deployable and Mobile Forces, Mr. James Terhune and Mr. Anthony Pezzano, OPM Mortars
- Precision Guided Miniature Munitions, Mr. Mark Carlson, BAE Systems
- The 81mm Non Lethal **Mo**rtar **Ca**rrier **P**rojectile (MoCaP), Mr. Seungeuk Han, Mr. Andrew Ponikowski, and Mr. Raymond Trohanowsky, US Army RDECOM-ARDEC
- Commercial Disposal of Explosive Wastes, Mr. Mark M. Zaugg, EBV Explosives Environmental Company

NATIONAL DEFENSE INDUSTRIAL ASSOCIATION

"Translating Lessons Learned into Systems Requirements"

40th Annual Armament Systems: Guns - Ammunition - Rockets - Missiles Conference & Exhibition

April 25 - 28, 2005

Sheraton New Orleans Hotel
New Orleans, LA

Monday, April 25 2005

10:00 a.m. On-site Registration

Noon Exhibit Move-In

5:00 p.m. - 6:30 p.m. Reception in the Exhibit Hall

6:30 p.m. Adjourn for the Day

Tuesday, April 26, 2005

7:00 a.m. On-site Registration / Continental Breakfast

7:45 a.m. Opening Remarks

8:00 a.m. ***Mr. David C. Schulte***, Executive Director, Naval Ordnance Safety & Security Activity

8:30 a.m. ***Dr. James C. Bradas***, Associate Director for Missile Technology, AMRDEC

9:00 a.m. **Session: Modeling & Simulation**

Accuracy Modeling of the 120mm M256 Gun as a Function of Bore Centerline Profile
Mr. David Smith for Dr. Ronald G. Gast, Benet Laboratories

Opening New DOORS to Managing JSF Gun System Requirements
Ms. Renee I. Bellack, General Dynamics Armament and Technical Products

Optimized Trajectory Shaping Guidance for an Air-to-Ground Missile Launched from a Gunship
Mr. Shane Sorenson, Naval Surface Warfare Center

9:30 a.m. Exhibit Hall Opens

10:00 a.m. Break in the Exhibit Hall

10:30 a.m. Conceptual Weapon System Design for the Defense of Naval Vessels from the Swarming Small Boat Threat
Mr. John E. Bibel, Naval Surface Warfare Center Dahlgren Division

Warhead Penetration Dynamics - Warhead Body, Fuze, and Target Interaction
Mr. Richard Ventura, Talley Defense Systems

Ballistic Limits of Skin and Clothing for Lethality Estimates of Projectiles Wound Ballistics
Mr. Henry E. Hudgins, US Army ARDEC

A Review of the Recent NIMIC IM Design Technology Workshop
Mr. M. Pascal Marchandin, NATO - MSIAC

11:50 a.m. Luncheon: Super Weapons From a Historical and Psycological Basis
LTC Simon R. West, British Army, United Kingdom Defence Academy

1:10 p.m. **Session: Medium Caliber Systems**

Ammunition for the New Infantry Battelfield Environment
Mr. Allan N. Buckley, BTECH Oerlikon Contraves Pyrotec AG

Force Protection - Multi Mission Vehicle Armament & Air Burst Munition for Expeditionary Warfare
Mr. Andrew Bradick, Lockheed Martin

F-35 Joint Strike Fighter Gun Overview and System Update
Mr. David L. Maher and ***Mr. Douglass C. Parker,*** General Dynamics, Armament and Technical Products

Phalanx Targeting Investigation
Mr. Jeff A. Siewart, Arrow Tech Association

3:00 p.m. Break in the Exhibit Hall

3:30 p.m. **Session: Medium Caliber Systems (Continued)**

Mk 110 Mod 0 / 57mm Gun Test & Certification Process
LT Timothy J. Hackett, USCG, US Coast Guard

GAU-19/A Barrel Life Study
Mr. James J. St. Germain, General Dynamics Armament & Technology Products

Calibre Choice for the Dutch IFV
Mr. Eelko van Meerten, TNO Defence, Safety & Security

The Expeditionary Fighting Vehicle, How Operational and Combat Lessons Learned Apply to the EFV and the 30MM Mix of Tomorrows Warfighter
Maj Kirk D. Mullins, USMC, DRPM AAA

30x173mm HEAB-T Development and Lessons Learned
Mr. Paul A. Reynolds, General Dynamics - OTS

5:30 p.m. - 7:00 p.m. Reception in the Exhibit Hall

7:00 p.m. Adjourn for the Day

Wednesday, April 27, 2005

7:00 a.m. On-site Registration / Continental Breakfast

7:45 a.m. Opening Remarks

8:00 a.m. ***BG (P) James R. Myles, USA***, Commanding General, US Army Test & Evaluation Command

8:45 a.m. ***Mr. Robert Salyer***, Raytheon

9:10 a.m. Acquiring and Sustaining US Army Missiles
COL Lloyd E. McDaniels, USA, CCWS Project Office

9:30 a.m. Exhibit Hall Opens

9:45 a.m. **Session: Medium Caliber Systems (Continued)**

Recent Developments of the M230 30MM Chain Gun
Mr. Lawrence A. Mason, ATK Ordnance & Ground Systems

MK44 Automatic Cannon Update
Mr. Mark McMillian, ATK Ordnance Systems

10:30 a.m. Break in the Exhibit Hall

Concurrent Sessions

10:50 a.m. **Session: Weapon Systems**

AC-130U Gun System Production Re-Start
Mr. John G. Fletcher, General Dynamics Armament and Technical Products

Weapon System Concepts for a Future Gunship
Mr. Michael M. Canaday, Naval Surface Warfare Center

Royal Navy Small Calibre Gun Research to Defeat the Small Boat Threat
Mr. Johnathan Watkins, Defence Scientific Technology Laboratory

11:50 a.m. - Lunch

1:00 p.m. **Session: Weapon Systems (Continued)**

Remote Operated Small Arms Mount (ROSAM)
Mr. Benjamin J. Hardie, General Dynamics Armament and Technical Products

Placing Gunner's Behind the Proctective Armor of Vehicles
LTC Kevin P. Stoddard, USA, PM Soldier Weapons

Picatinny High Speed Turret (PHIST)
Mr. Richard Ciekurs, US Army RDECOM-ARDEC

Session: Missiles & Rockets

Critical Asset Defense - ABRAHAM Rocket Assisted Projectile
Mr. Robert Daunfeldt, Bofors Defence

Hypervelocity Propulsion System Substantially Improves 2.75 Rocket Lethality, Safety, Survivability
Mr. Larry Bradford, CAT Flight Services, Inc.

APKWS Flight Test Results
Mr. Larry S. Ingram, General Dynamics Armament and Technical Products

APKWS Block II Demonstration Program
Mr. Milton E. (Gene) Henderson, Jr., US Army RDECOM-AMRDEC

Lunch

Session: Missiles & Rockets (Continued)

Missile System Lethality Enhancement Through the Use of Pulsed Power and Plasma Conduction
Mr. Allen H. Stults, US Army RDECOM

Next Generation Adaptable RF Seekers for Precision Munitions
Dr. Cory Myers, BAE Systems

The Smart Rocket Launcher as the Key Enabler for the Rocket System of the Future: The Technology Developments Needed for the Next Generation Rocket Laucher to Carry 70mm Rockets into the 21st Century
Mr. Donald E. Davis, US Army Research, Development & Engineering Command

	Session: Weapon Systems (Continued)	**Session: Missiles & Rockets (Continued)**
	Recent Activities Involving 40mm CTWS in Support of UK and France ***Mr. Michael Duckworth***, CTA International	Development of a Unique Penetrator Warhead for Rocket or Missile Delivery ***Mr. Roger W. Melin***, Lockheed Martin Missiles and Fire Control
	The Marine Corps Expeditionary Fire Support System (EFSS): A Systems Overview ***Mr. Jason Burkett***, General Dynamics	Determining the Army Aviation Rocket and Missile Mix for the Future Fight ***Mr. William M. Mulholland***, Whitney, Bradley & Brown
2:40 p.m.	Break in the Exhibit Hall ***(Last Opportunity to Visit Exhibits)***	Break in the Exhibit Hall ***(Last Opportunity to Visit Exhibits)***
3:00 p.m.	Exhibit Hall Closed	Exhibit Hall Closed
3:10 p.m.	**Session: Large Caliber**	**Session: Energetics**
	Development of the XM1028, 120mm Anti-Personnel Tank Round ***Mr. Hugh MacMillan***, Armaments Engineering and Technology Center, ***Mr. Peter Georgantzis***, US Army ARDEC, and ***Mr. Neal Hylton***, General Dynamics-OTS	Advanced Propelling Solutions Complying with Demands (FCS) ***Dr. Beat Vogelsanger***, NITROCHEMIE Wimmis AG
	Titanium Investment Casting Weapon System Application ***Mr. Jeff Lehner***, Director, Military Programs, Alcoa/Howmet Corporation	Development, Evaluation and Lifetime Prediction of Medium and Large Caliber Ammunition ***Mr. Gert Scholtes***, TNO
	Advanced Modular Gun Demonstrator - XLT Test Gun ***Mr. Steve Coladonato***, Applied Ordnance Technology, Inc.	Concepts and Practice in the Application of Lessons Learned ***Mr. David F. Fair***, US Army ARDEC
	The Modified Ammunition, Equipped with the "Fuzaman": The IMI 105-mm Heat-AP-t Cartridge M152/6 ***Mr. Danny Schirding***, Israel Military Industries, Ltd	Propellant Replacement for the 105-mm Artillery Propelling Charge ***Ms. Adriana L. Eng***, US Army ARDEC
	105/120/125 mm PELE Firing Results ***Dr. Lutz Borngen***, Rheinmetall Waffe Munition	Environmentally Benign Substitute Compounds for Lead Azide ***Mr. John M. Hirlinger***, US Army RDECOM-ARDEC
	Lightweight Gun Development and Testing for the Future Combat System ***Mr. David C. Smith, P.E.***, USA Benet Laboratories	Modeling Efforts in Support of PKERS Concept Development ***Mr. David C. Rutledge, Ph.D.***, Staff Engineer, United Defense
5:15 p.m.	Adjourn for the Day	Adjourn for the Day

Thursday, April 28, 2005

7:00 a.m. On-site Registration / Continental Breakfast

7:45 a.m. Opening Remarks

8:00 a.m. ***COL Mark Rider, USA***, Project Manager, Maneuver Ammunition Systems

8:30 a.m. ***Mr. Anthony Sebasto***, Associate Director for Technology & Business Development, AETC

9:00 a.m. ***Mr. Dave Broden***, NDIA Armaments Division Status Overview, Chairman, Armaments Division, NDIA

9:20 a.m. Break

Concurrent Sessions

9:40 a.m.

Session: Technology & Manufacture

Automated Ammunition Identification
Mr. David F. Pouliot, United Defense L. P.

Deep Digger Weapons System Concept
Mr. David W. Burns,US Army ARDEC

Development of Composite Launch Tubes for Shoulder Fired Weapons through Applied Science, Planning and Teamwork
Mr. Thomas P. Jacobson, Talley Defense Systems

Design for Manufacture & Assembly (DFMA)
Mr. Steve Watts, US Army RD&E Command

Technology and Manufacturing Initiatives
Mr. Dave Burkhardt, Enterprise Management Office, US Army ARDEC

Session: Technology & Manufacture (Continued)

Army MEMS Common Guidance Program
Mr. David. W. Panhorst, US Army ARDEC and ***Dr. Vicki C. LeFevre***, AMRDEC

Development and Testing of HE Projectiles for EM Gun - STO
Mr. Manfredi Luciano, US Army ARDEC

Session: Mortars & Artillery

Tank 120mm Training Ammunition: MB65 Target Impact Dispersion Study
Mr. Jason W. Gaines, General Dynamics-OTS

Lessons Learned from the Development of the U.S. Navy 5-inch Ship Self Defense Projectiles
Mr. Sanford L. Steelman, III, Naval Surface Warfare Center

ONR's Advanced Gun Barrel Technology Program
Mr. Allen Boutz, United Defense

Structural Margin Improvement on the M829A3 Projectile
Mr. Scott Carney, ATK

Session: Mortars & Artillery

Excalibur: Turning the Field Artillery into a Long Range Precision Attack Weapon System
Mr. Stefan Blomgren, Bofors Defence

Low Cost Course Correction (LCCC) Demonstration Program
Mr. George B. Barnych, General Dynamics Ordnance and Tactical Systems Division

Session: Technology & Manufacture (Continued)

Advanced Metal Injection Molding Technology Applications to Defense Industry
Mr. Jerry LaSalle, Polymar Technologies

11:40 a.m. Lunch

1:00 p.m. **Session: Technology & Manufacture (Continued)**

TBX Evaluation Testing in the M151 (2.75") Warhead as Risk Reduction for the APKWS
Mr. Jason C. Gilliam, US Army RDECOM-AMRDEC

Advanced Precision Kill Weapon System
Mr. Ulf Einefors, Bofors Defence

Test Results of an Imaging LADAR Seeker for Small Missiles
Mrs. Sarah J. Hard, RDECOM-AMRDEC

Session: Mortars & Artillery (Continued)

Applying Six Sigma Principles to Implementation of the PGMM Training Concept
Mr. Anthony Pezzano, OPM Mortars

Lunch

Session: Mortars & Artillery (Continued)

Precision Guided Miniature Munitions
Mr. Mark Carlson, BAE Systems

Development of a Non-Lethal Mortar Delivery System
Mr. Seungeuk Han, US Army RDECOM-ARDEC and ***Mr. Andrew Ponikowski***, US Army, RDECOM-ARDEC

Explosive Waste Recycle and Disposal
Mr. Mark M. Zaugg, EBV Explosives Environmental Company

3:00 p.m. **Conference Adjourns**

GENERAL DYNAMICS

Ordnance and Tactical Systems

Low Cost Course Correction (LCCC) Demonstration Program

NDIA 40th Annual Armament Systems:

Guns – Ammunition – Rockets – Missiles

Conference Presentation

Session: Mortars and Artillery

28 April 2005

Presented by:

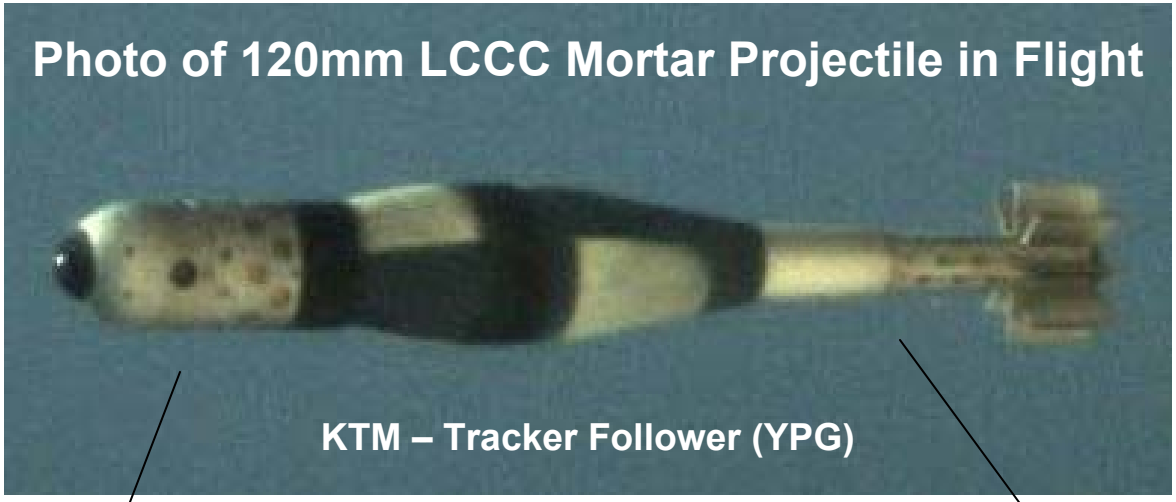
George Barnych **Daniel Davis**

Objectives

- Develop an Ultra Low Cost Semi-Active Laser (SAL) Seeker Compatible with All Currently Fielded Laser Designators
- Develop an Ultra Low Cost Projectile Maneuvering Mechanism
- Implement Autopilot Control Without the Use of Inertial Sensors or Other IMU Related Technology
- Design the System for Retrofit to Existing Projectiles
- Use COTS Electronic Components – No ASIC or Other Large Scale Integration (LSI) Effort

Achieve Lowest Possible Unit Cost

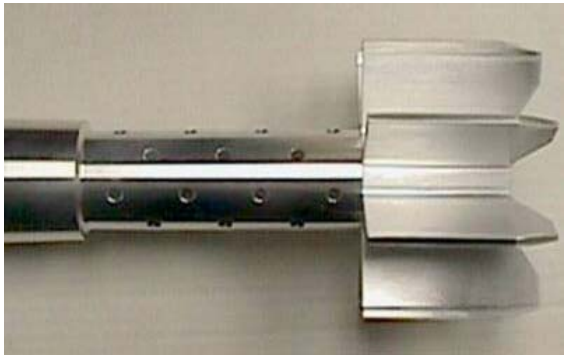
Resulting System



Seeker Electronics

Divert Control

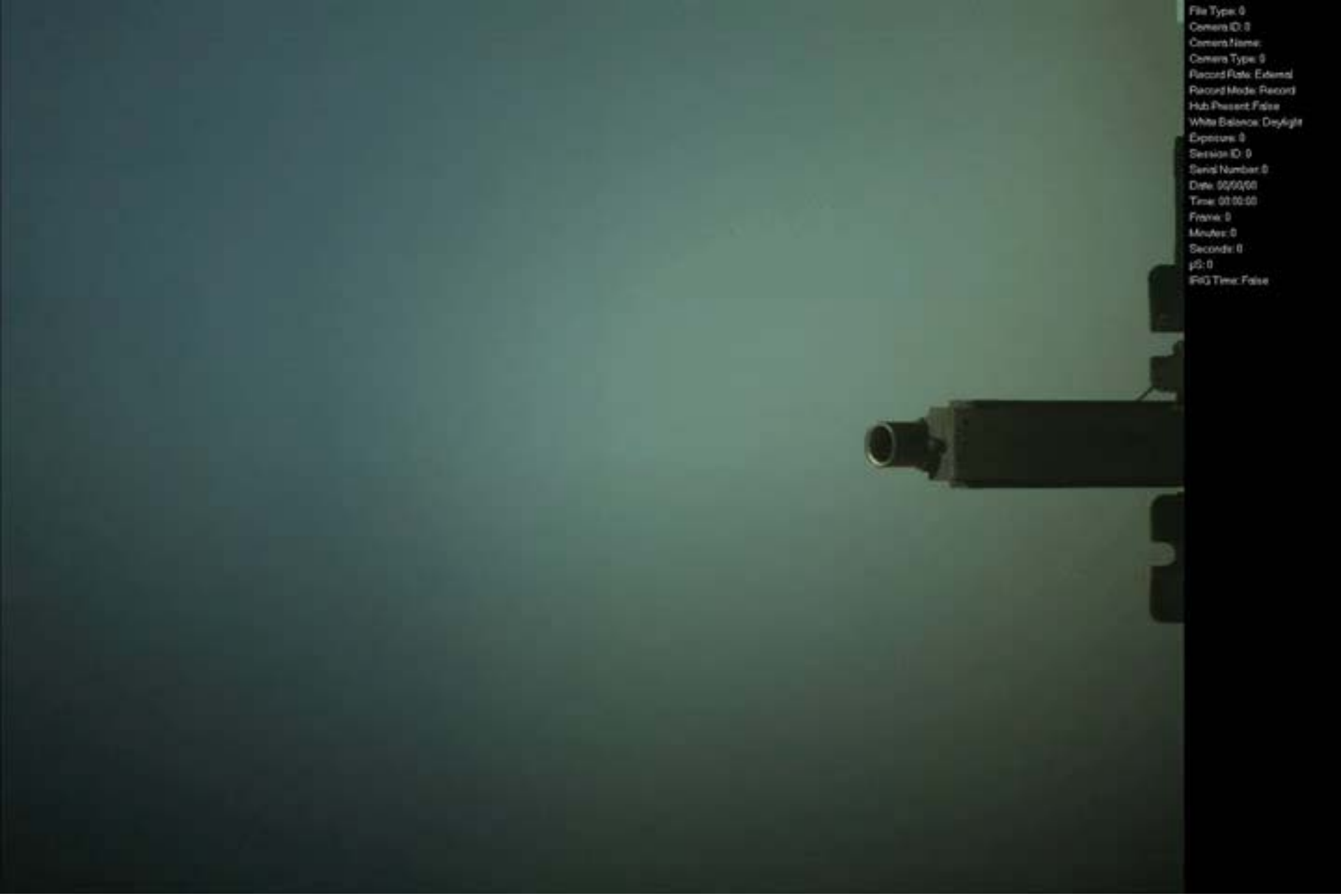
1° Fin Cant & Boom Extension



Test Setup

- **7km Test Range @ Yuma Proving Grounds (YPG)**
  - Gun Position 8, KOFA Firing Range, Yuma Test Center
- **Lanyard Initiated 120mm Mortar Tube**
  - Cannon, M298 120 mm Mortar MANN Barrel, Serial Number 01
  - Carriage, 105 mm Towed Howitzer, M101, (modified for 120 mm Mortar System)

- **KTM Cameras**
- **Mortar Tracking System (MTS) Radar, Weibel Radar**
- **On-Board Impact Survivable Recorder**
- **AN/TVQ-1 Laser Designator**
- **Stationary 16’ x 16’ Target**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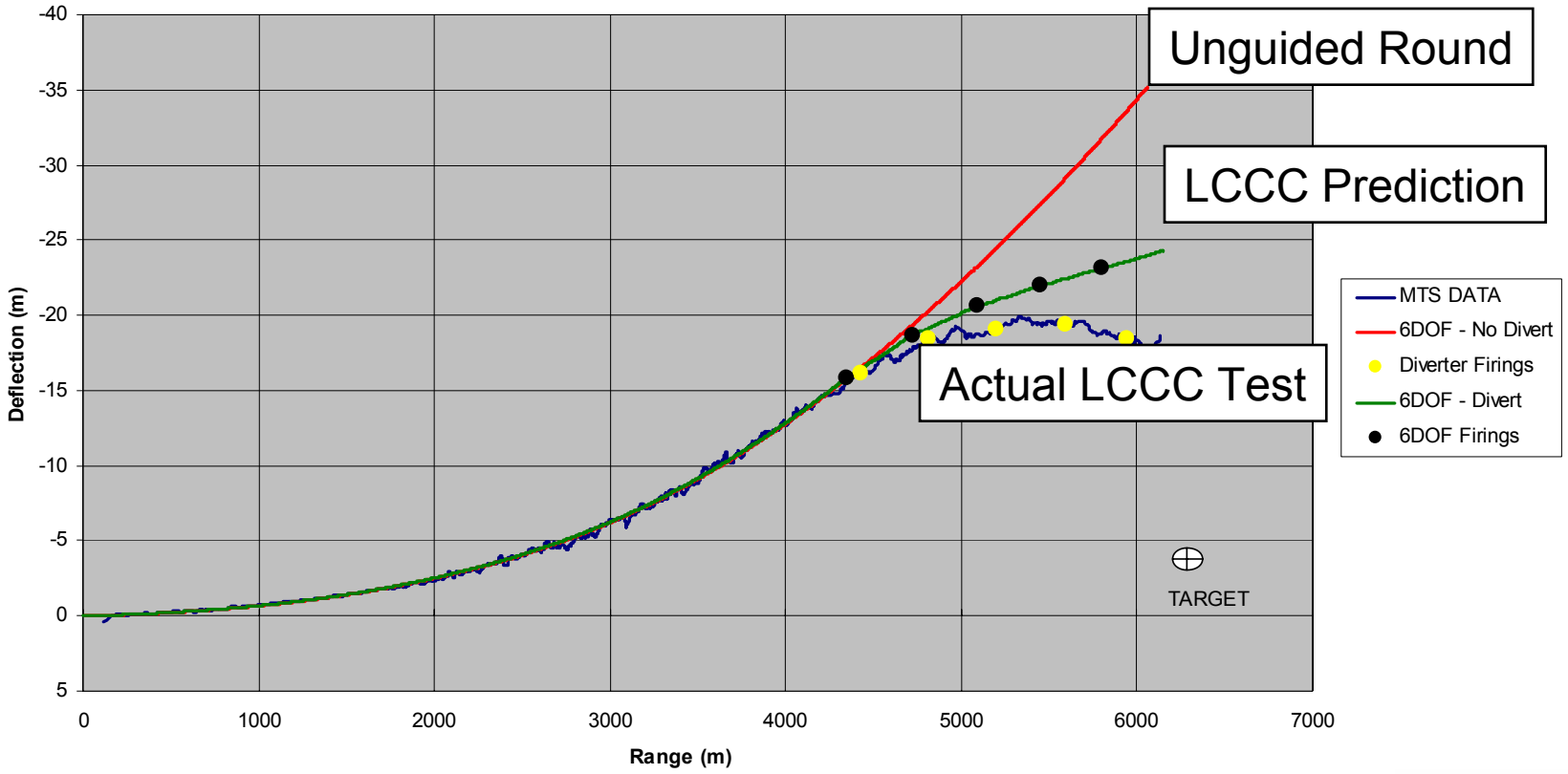
Test Results

3.3 LCCC Lofted Ballistic Evaluation (Task 3)

LCCC Test #1834

Single Pulse Mode LCCC Diverter Test

- 23m Deflection Achieved with 5 of 16 Diverters



Summary

- **Most Objectives of the Project Were Achieved**
  - **System Successfully Survived Zone 4 Gun Launch**
  - **A Very Low Cost SAL Seeker Technology Was Developed and Demonstrated Successfully**
  - **Diverters Were Able to Move the Projectile Towards the Laser Target Spot**
- **Issues Uncovered**
  - **Only 5 of 16 Available Diverters Were Fired**
    - Glass Beads Alone Deemed not Adequate to Protect Divert Fire Set Electronics During Multiple Shock Events – No Potting Was Used
    - Neglected to Conduct Sufficient Electronics Reliability Tests Against Multiple Divert Shock Impulses

Follow-On Demonstration Efforts Due in CY05

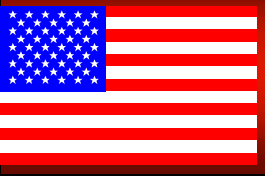
EXCALIBUR

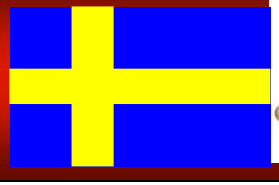
XM982

Precision Fires for the Field Artillery

John Halvey - Raytheon
Stefan Blomgren – Bofors Defence

Excalibur Program





- Joint International Program:
  - Kingdom of Sweden
  - United States

- In theater with US Army by March 2006
  - In Response to Urgent Need Statement
  - 15 months earlier than otherwise planned
- Fields to Swedish Army by 2009

BOFORS DEFENCE

Raytheon

Team Excalibur

EXCALIBUR XM982

PROJECT MANAGER COMBAT AMMUNITION SYSTEMS — VOLUME LETHALITY PRECISION CAS

Raytheon

BOFORS DEFENCE

TACOM ARDEC

TSM CANNON

FMV

KLUNE INDUSTRIES
SPANISH FORK, UT
Metal Parts

EAGLE PICHER
JOPLIN, MO
Batteries

HONEYWELL
MINNEAPOLIS, MN
IMU

American Ordnance
Middletown,IA
Warhead LAP

L3 - KDI
CINCINNATI,OH
FSA & HOB

BOFORS DEFENCE
KARLSKOGA,SWEDEN
Base, Airframe, Warhead

GD - OTS
REDMOND, WA
SRMBA

M/A COM
LOWELL, MA
Antennas, Tac TM

GD-OTS Healdsburg
HEALDSBURG, CA
CAS

NAMMO
RAUFOSS, NORWAY
Basebleed

PRIMUS
WILLIAMSPORT, PA
MC & PCU CCA's

EDO - CCS (ANC)
SIMIVALLEY, CA
Anti Jam

GD - DRI
ANNISTON, AL
CAS Prod/Metal Parts

L3 - IEC
ANAHEIM, CA
GPS Receiver

Raytheon-NAPI
FARMINGTON, NM
GNC Production Line

McAlester AAP
McALESTER, OK
Final Integration

GD - OTS
ST. PETERSBURG, FL

BAE
PLYMOUTH, ENGLAND
IMU

RAYTHEON MISSILE SYSTEMS
TUCSON, AZ

RAYTHEON ELECTRONICS
MC KINNEY, TX
Radome

GD –OTS OTI
NICEVILLE, FL
Warhead

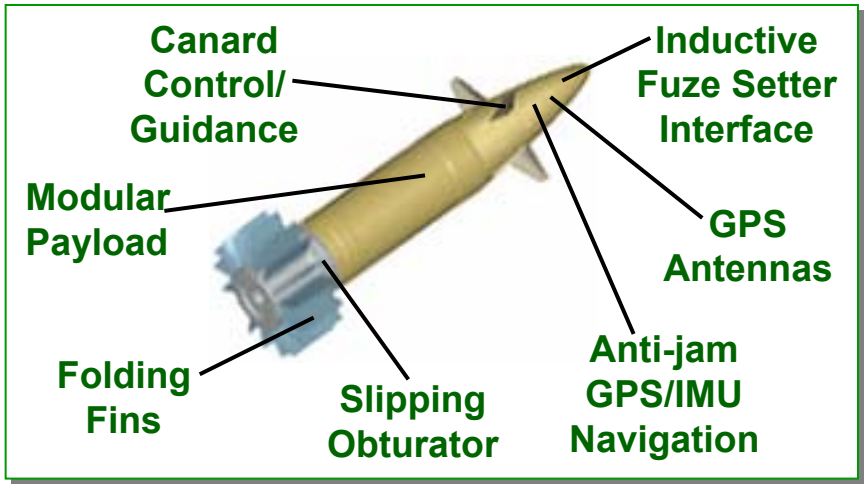
BOFORS DEFENCE

Raytheon

Excalibur System Description

Excalibur:

- Precision Guided, Extended Range 155mm featuring varying payloads and capable of being fired from any 155 mm Howitzer



Block I (Unitary):

- HE Warhead
- GPS/IMU Guidance

Block II (Smart):

- Detect/acquire/engage submunition capability

Block III (Discriminating):

- Terminal Guidance

Required Capabilities:

- 10m CEP accuracy regardless of range
- 35/50 km max range (T); 40/60 km max range (O)
- Retains traditional HE target sets
- Penetrates 4” reinforced concrete
- Almost vertical terminal trajectory for urban terrain (expands artillery target sets)

BOFORS DEFENCE

Raytheon

The Benefits Of Precision Fires

Target/Environment	Precision Fires Excalibur (< 10 m CEP)	Precision Area (< 50 m CEP)	Area M107
Point CP, ADA, Building, Vehicle	✓		10 - 35 X®
Area Platoon In Open	✓	✓	10 X®
Massed Fires Suppression, Large TLE	✓	✓	✓
Collateral Damage Danger Close	✓	✓	
Range	✓		✓
Urban Terrain	✓	✓	✓
Reduced Logistics/Costs	✓	✓	

BOFORS DEFENCE

Raytheon

Artillery Precision Vs. Other Precision

- Immediately Responsive Fires
  - Air Power Superb; But Not 100% Available or Always the Correct Response – Collateral Damage
  - Organic to Modular Brigades
- Fire and Forget Accuracy Not Dependent on SAL
  - Pinpoint Accuracy; Not Always Available, Can Not Always Perform
- All weather
  - If The Close Combat Force Finds the Target, GPS Accuracy Engages
- Low Cost Precision Compared To Aviation Delivered
  - Consider Sustaining The Force In the Field
  - Consider Stowed Kills
  - Consider Required Organic Fires for Close Combat Force

BOFORS DEFENCE

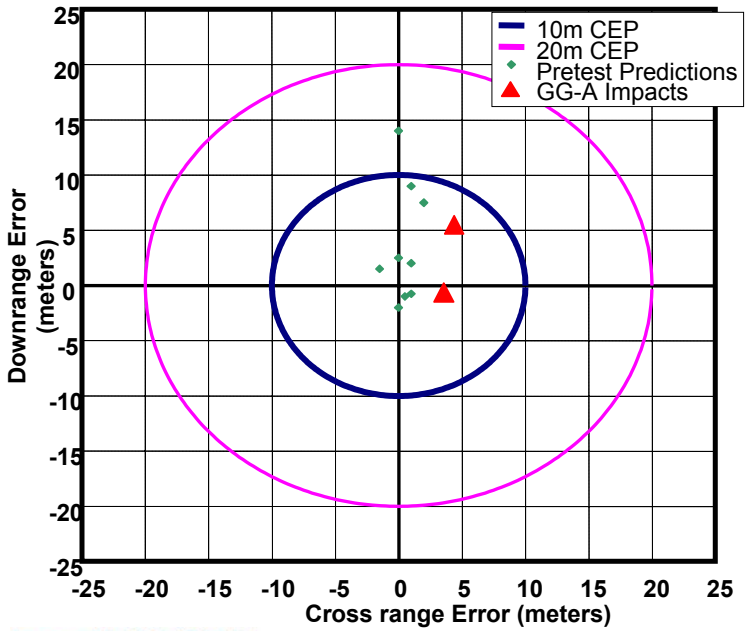
Raytheon

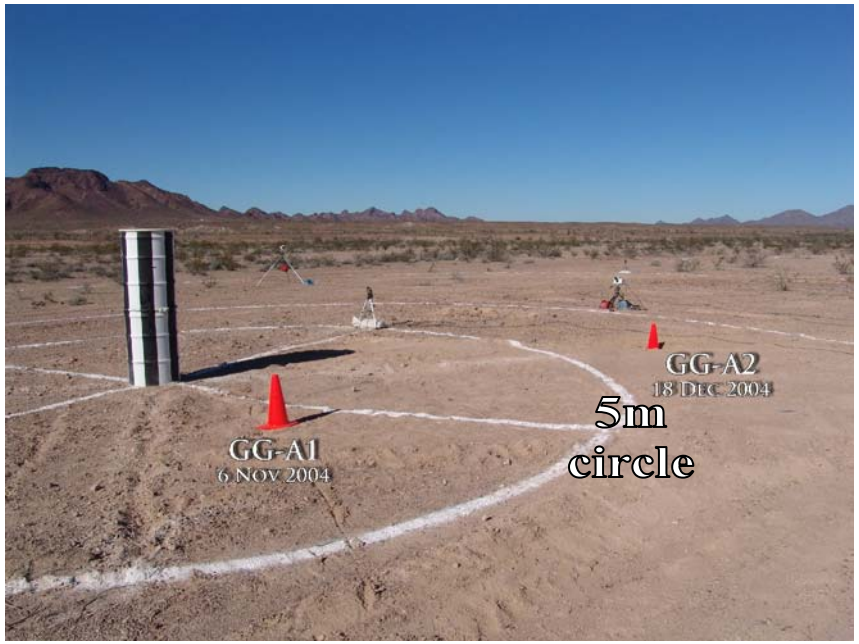
Accuracy Independent of Range

EXCALIBUR XM982

Guided Gunfire A (GG-A) Test (6 Nov & 18 Dec 04)

- **Fired from LW155 & Paladin**
- **Range to Target: 20 Kilometers**
- **Demonstrated Accuracy: 3.4 m & 6.9 m**
  - First Shot Fired in Greater Than 75 mph winds





BOFORS DEFENCE

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FOR PUBLIC RELEASE

System Integration (Level 3)

EXCALIBUR XM982

Setting up the of the Gun and programming of the Projectile is automatically performed as an integral part of the firing cycle.

Automatic Ramming of Projectiles will normally require this fully Integrated System of Systems.

NLOS-C
- **Future US Army**

ARCHER
- **Future Swedish Army L52 Gun**

Full Integration of System of Systems allows for no-man-in-the-loop and sustained firing rate.

BOFORS DEFENCE

Raytheon

System Integration (Level 2)

Digitally integrated Gun Systems, with manual EPIAFS programming of the Projectile prior to ramming.

The Projectile is programmed thru the EPIAFS which gets its feed from the Gun Integrated Fire Control, which also sets up the gun.

US M777 (JLW155)

Paladin

FH77B

The Intermediate Integration level requires only Manual EPIAFS Programming of the Projectile

BOFORS DEFENCE

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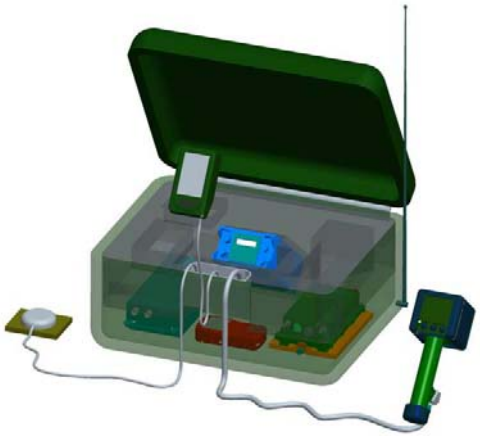
System Integration (Level 1)

The "Ghost Gun" will provide the link between the Projectile and the Fire Control System. It will program the Projectile for firing in any gun, while the gun will be set up independently.



A Stand-Alone "Ghost Gun" will give any 155 mm gun Excalibur capability

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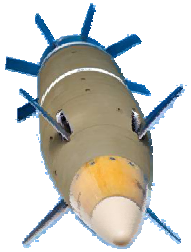
Excalibur Benefits Summary

- **Organic Fires Is the Most Responsive**
- **Flexibility to Execute Traditional and Evolving Missions**
  - **High Accuracy - Minimize Collateral Damage**
  - **Fire and Forget**
  - **All Weather**
- **High Lethality from Impact Angle & Accuracy**
- **Reduced Force Costs**
  - **Existing Ground Based Force Structure / Systems**
  - **Reduced Logistics (Trucks/Drivers/Cooks …)**
  - **As High As 50:1 Excalibur to Less Precise Rounds**
- **Will Integrate Across Current and Future Force Structures**



BOFORS DEFENCE

Raytheon

Guns, Ammunition, Rockets, and Missile (GARM) Systems

National Defense Industrial Association (NDIA)

Armament Division

2005 Division Status

25-28 April 2005

2005 Management Briefing Topics

1. Armament Division Objectives
2. Organization — Leadership
3. Symposium — Effectiveness
4. Charter Updates — Clarity — Current Focus
5. National Small Arms Consortium/Center
6. Pentagon Outreach
7. Manpower Study
8. Defense Legislation Issues
9. Membership Participation
10. The Future Ahead

The Links – Who, What, Why

National

- All services
- Industry
- Jointness
- International

Defense

- Worldwide Threats
- Homeland Defense
- Readiness
- Technology and Operational Superiority

Industrial

- Industry Organization
- Spokesman for Industry
- Resources
- Capability/Readiness

Association

- Visions
- Innovative Solution
- Communication
- Sharing
- Jointness
- Linking Government and Industry

An Organization Ensuring Strength Through Industry and Technology

Bottom Line

NDIA Focus → Responsive to Industry/DoD Community → Ensures Relevance

Addressing Issues Critical to Guns and Ammunition, Missiles and Rockets Systems

Armament Division Focus

- Expanded participation
- Resource for government and industry
- Linked to key DOD and service strategies
- Capture "lessons learned" → ensure readiness → shape future
- Encouraging leverage of complementary systems
- Effective use of exhibits, demonstrations, and tours

Establishing Vision for 21st Century Relevance

Applying System Synergism to Meet Transformation Goals

Leadership

Objective: Coordinated Focus and Vision for Armament Systems

Armaments Division

Dave Broden

Committees

- Small Arms Systems — Brian Berger
- Guns, Ammunition, Rockets, Missiles (GARM Systems)
  - Guns/Ammunition — Bob Glantz
  - Rockets/Missiles — Ed DePasqual
- Future TBD — TBD

Themes, areas discussed; no specific action

Responsive Organization – Ensures Relevance

Scope – Area of Interest – Responsibility Definition Clarity

Expanding Cooperation with Related Sections

Committee Scope

GARM Systems

Small Arms Systems

- Individual weapon(s)
- Crew served weapon(s) (e.g., ≤ 40mm)
- Lightweight Systems
- Ammunition
  - Enhanced/lightweight
  - "Green"
- Full life cycle management
- Supportability
  - Training
  - Logistics
- Target Acquisition/Fire Control System (TA/FCS)
- Remote Stabilized Turret System
- System Integration
- Networked capabilities
- Non lethal
- Homeland Defense systems

Guns and Ammunition

- Medium caliber systems
- Tank systems
- Mortar systems
- Artillery systems
- Naval gun systems
- Aircraft/helicopter systems
- Precision systems
- Platform Integration
- Manned/robotic applications
- System integration
- TA/FCS
- Supportability
- Life cycle management
- Stabilized Turret System

Missiles and Rockets

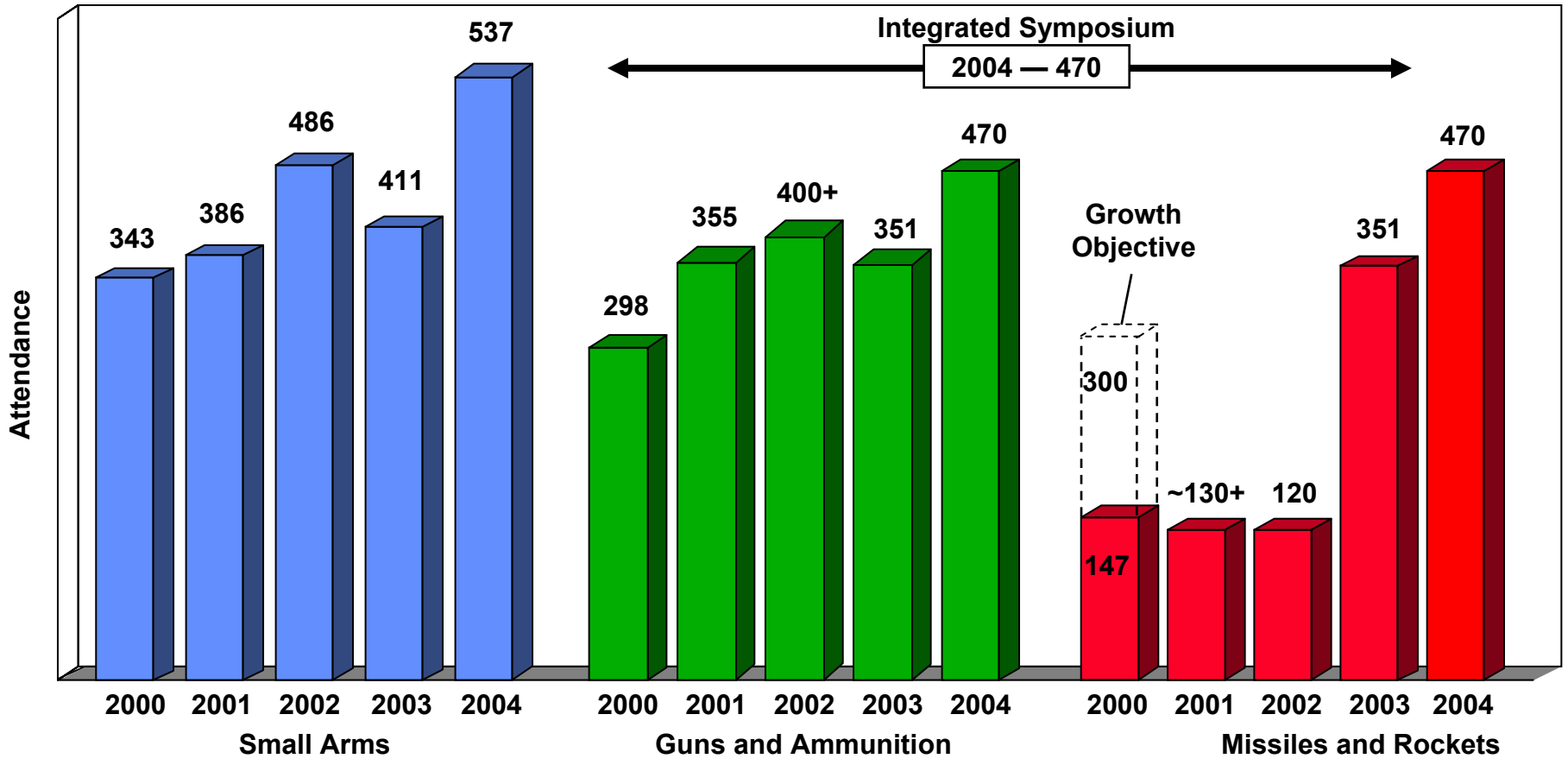
- Tactical missiles and rockets
- Shoulder Fired Systems
- Ground launched
- Aircraft/helicopter launched
- Precision Systems
- System Integration
- Manned/robotic applications
- Life cycle management

Synergism → Commonality

Common Enabling Technologies, Modeling/Simulation, Man-Tech

Links to Other Committees

Armament Division Attendance Summary



Guns and Ammunition

Rockets and Missiles

Translating Lessons Learned into System Requirements

Addressing the Theme!

- **Joint Capability**
- **Joint Requirements**
- **Readiness Capability**

Applying Common Advanced Technologies and Integrated Systems

- Capability focused complementary integrated systems
- Address key force multipliers
  - Precision
  - Mobility
  - Communication
  - Situation awareness
  - Lethality
- Planning and implementing Spiral Development
- Building on “lessons learned” for future readiness
- Ensuring responsive industrial base capability
- Attention to life cycle management

Enabling an Integrated Joint Force Capability

Linking to Theme

Translating "Lessons Learned" into System Requirements

- Understanding the Need
- Joint Requirement(s)
- Requirements Pull
- Technology Push
- Readiness/Capability/Responsiveness
- Direct Integration
- System Integration Adaptations
- Spiral Development
- Supportability

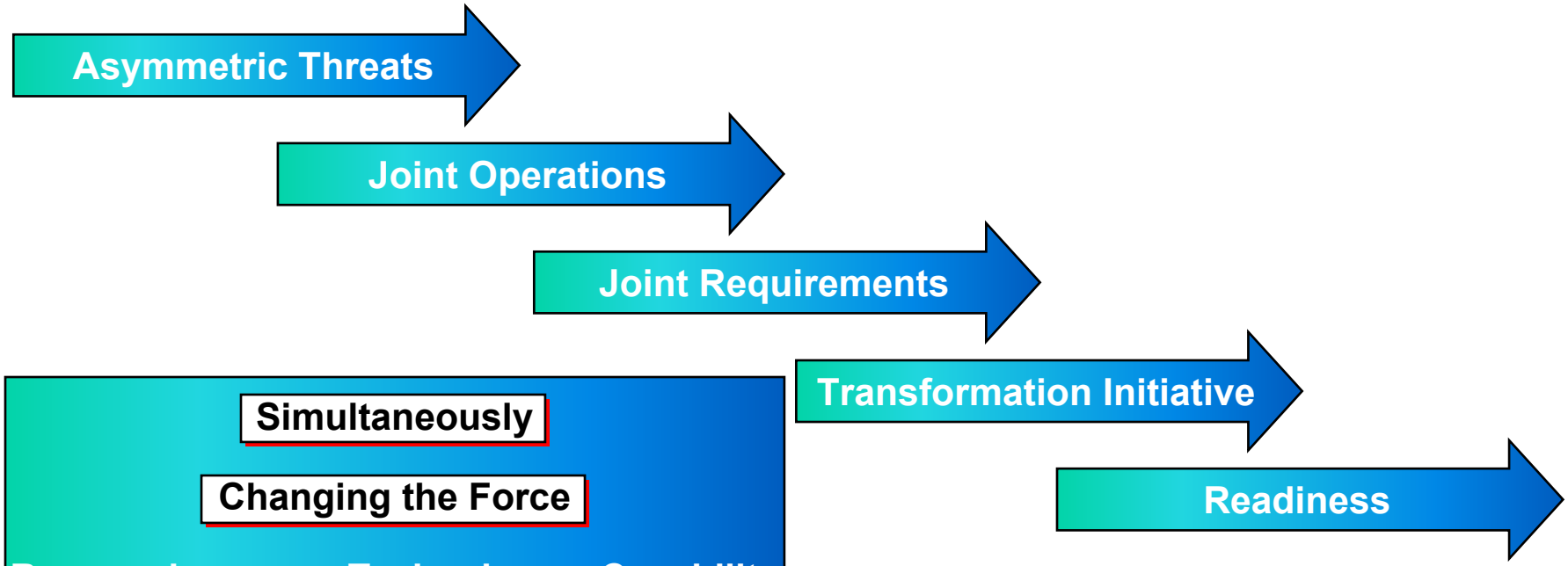
- Threat Specific Solutions vs. Capability Driven and Adaptable
- Operational Flexibility and Responsiveness
- Spiral Development

Response to Symposium Theme

– Adaptable, Innovative, Visionary, Capability Focused

Joint Services: Defining and Executing the Change

Industry: Ensuring Technology and Product Availability – Evolution



Small Arms Systems

Meeting the Needs of Our Joint Ground Forces in the Fight Against Terrorism and Developing the Tools for Future Combat

Address and Focus on the Theme

DoD and Homeland Defense Capabilities

- Joint Force operations and capability
- Response to asymmetric threats
- Adapt systems and technology for operational flexibility — Jointness
  - Responsiveness
- Push technology envelope(s)
- Push integration efficiencies
- Add functional capabilities
- Introduce new systems
- Ensure readiness and capability

"Lessons Learned" — Readiness/Capability — Responsive Force — Jointness — Technology Change

Shape the Future — Enable the Force

Armament Division Success

Guns and Ammunition/Missiles and Rockets

Small Arms Committee

Value Added Has Been Demonstrated

Leadership to Strengthen the Armament Community

Challenge: Applying Technology, Systems for Future Force

Ensuring Readiness . . . . Responding to the Challenge Advancing Superior Capability

Symposium Benefits Confirmed

Increasing Interest/Participation

Symposium Observations

Linking NDIA and DoD Realized

- Improved links to DoD and service thrusts and initiatives
- Interest in "after action reports" — "lessons learned" → industry responsiveness → addressing challenges

Symposium Quality and Communication Demonstrated

- Presentation quality improvements and "So What" benefit messages have added value
- Focused interest in systems level presentation vs. technology unless technology offers payoff vision
- Industry adjusted to intellectual property concerns and expanded participation positively
  - Industry worked with vision

Armament Division 2005

Ensuring Relevance

- Evolve executive committees
  - Integrate relevant organization(s) for future
    - Industry
    - Government
- Reshape and define division charters to ensure relevance/clarity
- Symposium themes
  - Future "vision" focus
  - Emphasize Readiness topics
- Symposium content
  - Emerging technology and capability
  - Panels
  - Interactive format
- Attendees
  - Participation is growing resource

Armament Division is Key to Current and Future Force Capability

Armament Division 2005 Highlights

1. Focus on relevant topics
2. Solid links to Transformation and future topics
3. "Lessons learned" and "after action reports" input shapes the future
4. Recognition of need to address industrial base readiness — capability — responsiveness
5. Executive committees focused to objectives → outreach links to DoD
6. National Small Arms Center established/operational
   - 50+ companies
   - Program planning addressing GAPs in-process
   - Procurements initiated
7. Continued panel discussions focus to key interest topics
8. Recognized forum for business/technology "networking"
9. Leadership in Navy SUW Study

Armament Division Charter Update

Objective: Ensure Armament Division charter responsive to DoD and industry trends and changes

Charter Format:
- Armament Division charter sets guidelines — objectives — criteria
- Appendices address sections/committees
  - Missions
  - Scope/definitions

Status: Committee updates in process
- Small Arms → expand/clarify scope
- Guns and Ammunition } Combined into Guns, Ammunition,
- Rockets and Missiles } Rockets, and Missile (GARM) Systems
- New area — TBD

Guns, Ammunition, Rockets, Missiles (GARM) Section/Committee

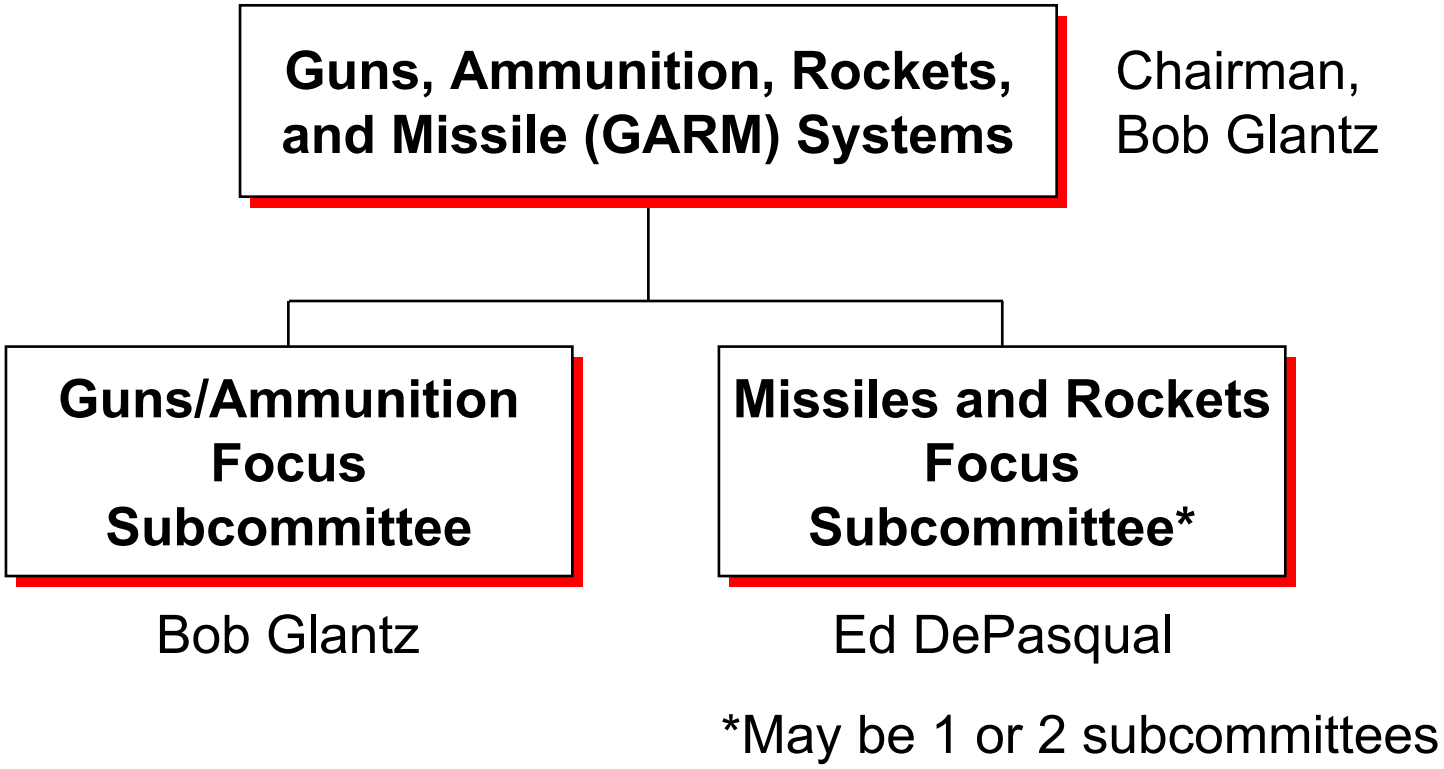
Committees were	Committee is
Guns and Ammunition	Guns, Ammunition, Rocket, Missiles (GARM) Systems
Missiles and Rockets	

Benefits Realized

1. Commonality NDIA membership
2. Leverages convergency of technology and systems
3. Stimulates discussions — dialogue
4. Symposium attendance efficiency (one vs. two meetings)
5. Brings separate communities together for common purpose

Symposium Interest, Attendance, and Dynamics Enhanced

GARM Committee Structure



Organization Focuses on Commonality and Synergism and Provides Links to the Two Components

Keys to GARM Committee Integration Effectiveness

- Communication of commonality/synergism between the two components
  Guns/Ammunition + Rockets/Missiles → Integrated Armament Approach
- Realizing convergence of technology and system integration
- Understanding complementary system capability → operational
- Integrating industry representatives on executive committee
- Integrating government agency representatives on executive committee

"Leaders and Expertise"
"Involved"

- User agency personnel participation → symposiums, executive committee

Establishing Symposiums and Special Projects Responsive to Attendees and Membership

Armament System Division Charter Vision

- A common vision for Armament System evolution
- A division responsive to changes and challenges
- Realizing complementary and synergistic capability
- Innovation in armament systems:
  Requirements/need → development → deployment/operation
- Increasing NDIA impact through symposiums, studies, exhibits, etc.
- Re-look at division structure in future to ensure relevance to DoD needs → change is opportunity = ensures responsiveness
- Enabling links to key DoD and service offices

NDIA Pentagon Outreach Program

- NDIA initiative to link NDIA divisions/committees and mission to key DoD offices — ensure partnership and interaction on issues/needs of mutual concern
- Armament Division approach
  - Identify key offices and positions linked to:
    - Guns and Ammunition system
    - Rockets and Missiles system
    - Small Arms systems
  - Establish Armament Division communication plan
    - Through NDIA management and from committees
    - Contact list
    - Briefing package → objectives, mission, challenges, issues, etc.
  - Special Studies suggestions

Communicate Recommendations to Armament Division Leadership

Pentagon Outreach Program Objectives

- Foster understanding of NDIA in target offices/positions
- Establish active relationship with target offices/positions
- Establish/increase knowledge of division events, studies, and other NDIA operations
- Educate target offices that NDIA represents defense industrial base and is key link between industry and government
- Inform target offices that NDIA is excellent source of advice, expertise
- Encourage DoD and services to utilize NDIA management, divisions, committees as a communication link

Partnership — Teamwork — Synergism

Armament Division Outreach Prior Successes!

1. Established Joint Service Operating Requirements for mechanical fuzing for ammunition (JSOR)
   - → Ensure increased safety, MIL-STD-1316 compliance, added functions, addressed commonality and affordability

2. Established guidelines and approach for helicopter gun systems
   - → Defined LW-30 Apache gun system approach

3. Harrier gun system → study led to selection of GAU-12 gun system for Harrier

4. Interface and meetings of industry with Joint Ordnance Coordinating Group (JOCG) addressed “ongoing” technology, system, and production issues and jointly solved problems in common meetings

Armament Division Outreach Prior Successes!

5. Joint Medium Caliber Gun and Ammunition Master Plan (JMAT) — establish roadmaps jointly developed by all services and industry to prioritize medium caliber systems

6. Naval Surface Weapon System Study — in process — OPNAV N76 sponsored

7. Joint Non-lethal Weapon System Planning and Workshop → integrated government, national labs, and industry for multi-year non-lethal plan

8. Committee of Small Arms Producers (CSAP) → ongoing to strengthen small arms base

9. Established National Small Arms Consortium — National Small Arms Technology Center

Armament Division Committee Actions

Pentagon Outreach Effectiveness Assured Through:

1. Committee/membership identification of key DoD/service target offices
2. Committee identified topics/issues for communication to target offices
3. Effective execution of special studies sponsored by target offices
   - Identified by committee
   - Requested by Pentagon

- **Armament Division Committees and Membership are Encouraged to Provide Input to Outreach Focus**
- **Executive Committee will Maintain Lists and Action Plans**

DoD-DDR&E Manpower Study

Objective

- To define DoD and industry manpower evolution and establish legislative recommendations to strengthen resource base
  - Baseline:
    - Shape 2006 version of 1958 National Defense Education Act (NDEA)
    - Other topics

Conclusion

- Science and technology workforce requires attention to maintain technology leadership and staffing levels
  - Education
  - Retention
  - Mentoring

NDIA International Symposium Links

Objective: International cooperation and integration of symposiums benefiting industry and Department of Defense to encourage partnerships for development, production, and interoperability

Approach:

- Coordination of NDIA Armament Division programs with "Symposium at Shrivenham" The Royal Military College of Science
- Common presentations and panel participants is a strong "open door" resource

European Small Arms and Cannon Symposium

August 2004

2005 Top Defense Issues

- Issue 1: Sustaining War on Terrorism, Military Readiness, and Future Defense Transformation
- Issue 2: Support the Defense Industrial Base
- Issue 3: Ethical, Accountable, and Balanced Process Reforms
- Issue 4: Securing the Homeland
- Issue 5: Improve Human Resource Programs

NDIA Board of Directors Approved Focus

Established by Government Policy Advisory Committee

Look to Web Site for Full Details

These Issues are NDIA Membership Voice to Congress

NDIA Communications

- National Defense Magazine
  - Emphasis on relevant and timely topics
  - Frequently source of media, DoD, and Congressional reference
- Website
  - Symposium presentations available — attendee access
  - Complementary information
  - Full list of activity
- Top public policy issues — prioritized — addressed to Congress — strengthen the community

NDIA Messages and Content Has Impact

and

Website Used Extensively as Resource

NDIA Leadership Actions

- Committee of Small Arms Producers (CSAP) Oversight
  – Results: Consortium/National Center → Operational 2005
- Establish focused Pentagon Outreach Program to targeted offices
- Facilitating responsiveness — readiness
- Division and Committee Links — leveraging commonality of resources, technology, systems
- Legislative affair "top issues" → seeking value added legislation
- Support DoD-DDR&E Manpower Resource Study
- Expanded effectiveness of exhibits/displays — "firing demonstration"

Take-Away Thoughts

- NDIA is strong and valuable
  - Resource use enables timely/responsive solutions
- Armament Division is transforming to ensure relevance
- Multi-discipline capability links NDIA divisions
- Listen to “lessons learned” and jointly enable readiness capability
- Commitment to “value added” change
  - Jointness
  - Transformation — future
  - “Lessons learned”
  - Capability driven
  - Readiness — capability — responsiveness
- Attendee participation strengthens organization

NDIA Membership Shapes the Organization Through Participation and Use

Leadership Vision

NDIA Armament Division Is:

- A relevant voice and forum
- Responsive to DoD community and industry challenges
- A forum for DoD/industry interaction discussion of "lessons learned" and needs
- Supporting national defense through people resources, networking, and symposiums
- Transforming to ensure relevance to changing military, geopolitical environments, technology, and industrial base resources

The NDIA Community is the Resource of Choice For Excellence in National Defense Topics/Communications

40th Annual Armament Systems: Guns – Ammunition – Rockets – Missiles Conference and Exhibition

ARDEC Business Development Process

Relentless Pursuit of Advanced Armaments Technologies

David L. Burkhardt
Director, Strategic Communications
27 April 2005
New Orleans, LA

ARDEC Business Development Begins with the Marketing Process

- Definition: A Process, Once Instituted, to Support Overall ARDEC Business Development Coordination on Customer Relationships Facilitating the Evaluation and Response to Customer Needs and Requirements
- A Corporate Marketing Function which will Set Targets for ARDEC and Communicate Planning without Diminishing Lower Level Marketing Efforts, which Exist Naturally
- A Single Point of Entry to the Customer, as Appropriate, while Maintaining the Ability to Act on Existing Relationships
- Continued Market Success will be Built on ARDEC's Integration of Domain (e.g. Fuze, Energetics, Fire Control) and Functional (i.e. Project Integration, Systems Engineering, Configuration Management) Expertise to Pursue, Capture and Deliver on Work for the Customer

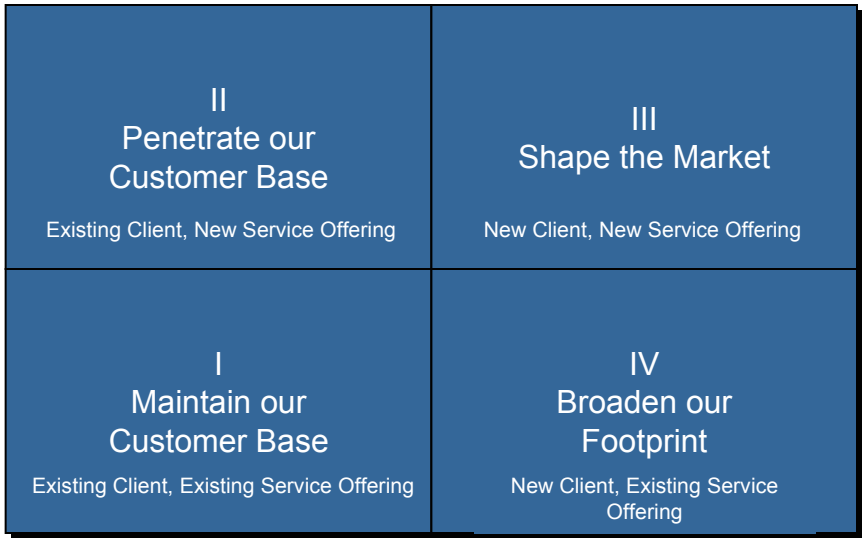
ARDEC's Business Development Framework is Driven by Available Market, Resource Utilization and Achieving an Acceptable Return on Investment

- ARDEC's Business Development Framework has been Divided into Four Main Areas (Quadrants)
- Each Quadrant Presents an Opportunity for ARDEC to Increase Business, Gain Market Share and Demonstrate Vision/Thought Leadership
- ARDEC's Business Development Process Enables a Thorough Vetting and Planning Process to Improve our Win Ratio, Maximize our Resources and Mitigate our Risks
- Business Development Activities will be Adapted to Efficiently use Resources and Gain Acceptable Returns on Investments
- There Must be a Balance Across the Four Quadrants to Achieve Steady Growth and Gain Future Market Positioning

ARDEC will Adapt its Business Development Activities to Address the Goals Presented by Each Quadrant

Marketing…each Quadrant Presents an Opportunity for ARDEC – Increase Business, Gain Market Share, Demonstrate Vision and Thought Leadership

Business Development Framework

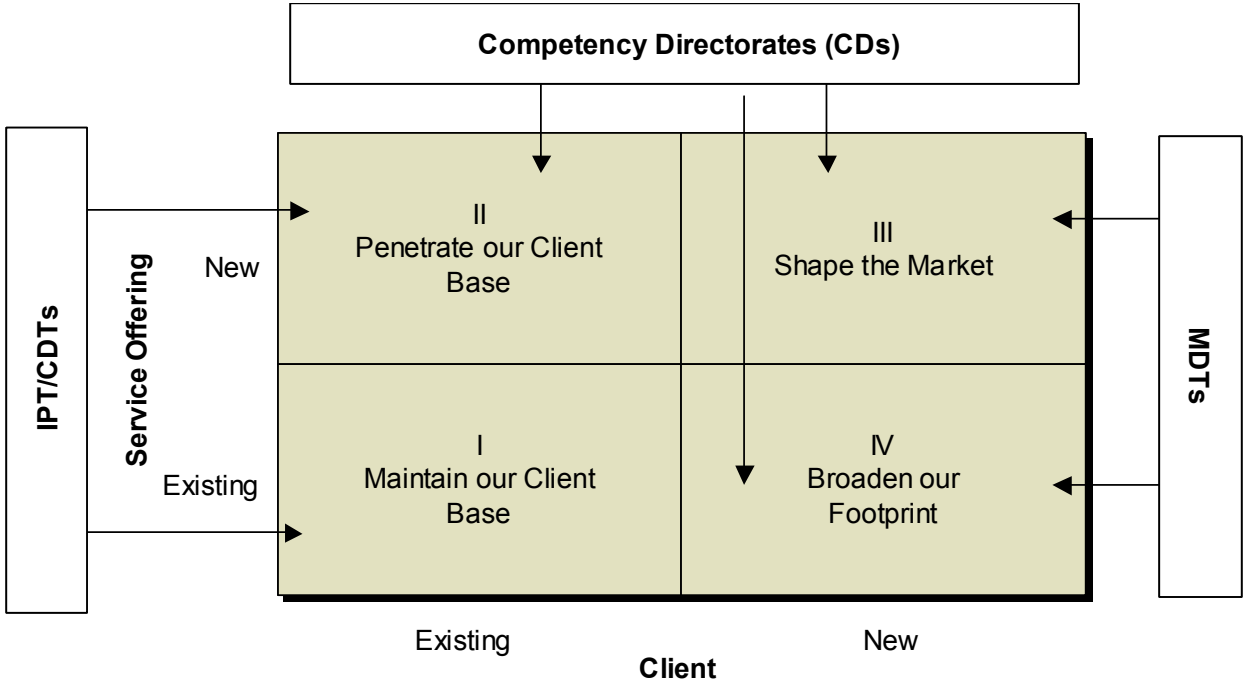


- There Must be a Balance Across the Four Quadrants to Achieve Steady Growth and Gain Future Market Positioning
- Currently, ARDECs Market Alignment is Approximated as Follows:
  - I – 75%
  - II – 10%
  - III – 5%
  - IV – 10%
- To Address the Goals Presented by each Quadrant and more Equitably Align to the Market ARDEC will Form:
  - Customer Development Teams (CDT) for Quadrants I and II
  - Market Development Teams (MDT) for Quadrants III and IV

MDTs and CDTs will Pro-actively Transition Technology to the Customer in Support of the Warfighter

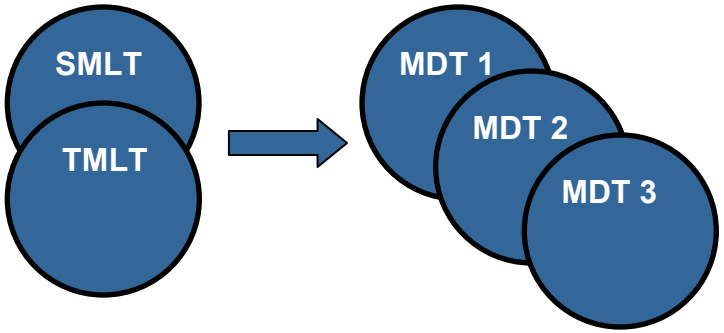
Marketing…Marketing Process Teams

- Marketing will be Coordinated Across ARDEC Organizations through Market Development Teams and Customer Development Teams
  - Market Development Teams (MDTs): A Team of Senior-level Cross Organizational Representatives that Work Together to Penetrate and Prosecute *New* Customer Groups
  - Customer Development Teams (CDTs): A Team of Cross Organizational Representatives that Work Together to Identify and Exploit Opportunities to Expand the Delivery of Current ARDEC Capabilities to *Current* Customer Groups.



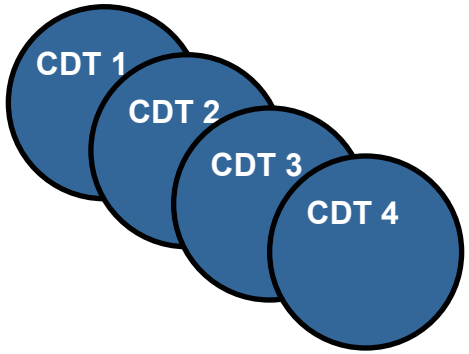
Market and Customer Development Team Structures

Market Development Teams



- The Strategic Market Leadership Team (SMLT) is an Overarching MDT that will Help to Define what Customers we wish to Target and Penetrate.
- The Technical Market Leadership Team (TMLT) is an Overarching MDT that will Help to Define what Technologies we wish to Market to Potential Customers.

Customer Development Teams

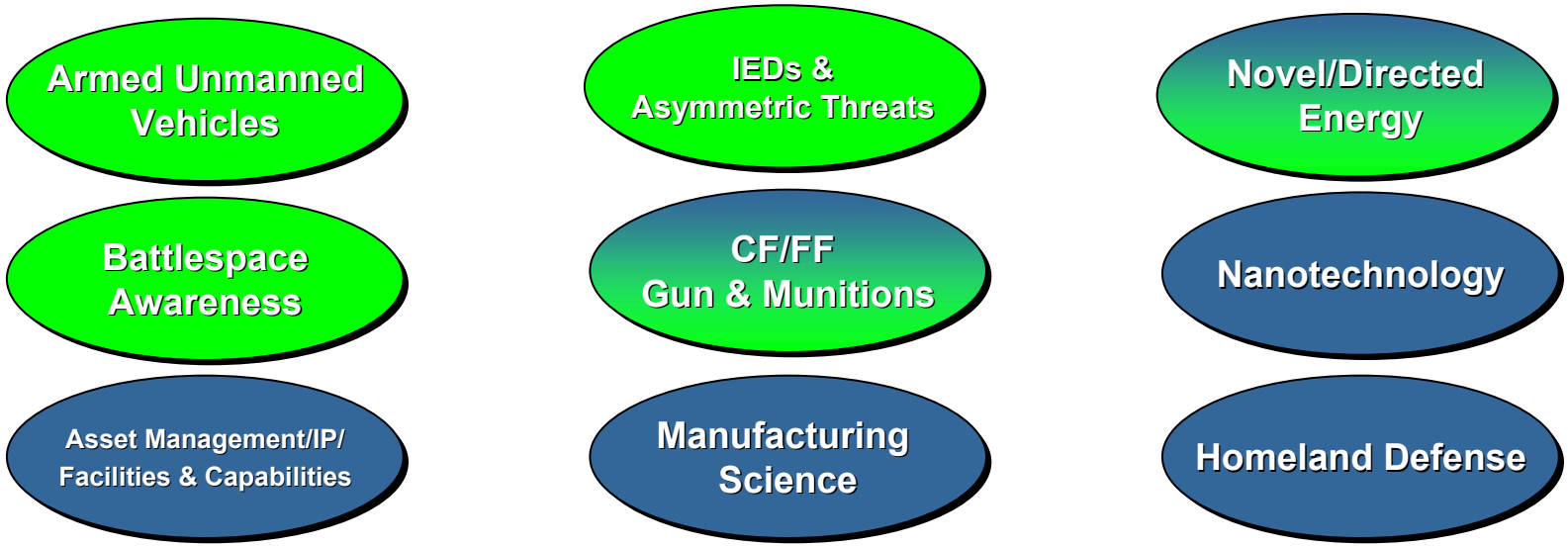


- Customer Development Teams are Created for each Customer to Expand the Delivery of ARDEC Products and Ensure that there Future Needs and Requirements are Addressed.
- Teams are Lead by a Customer Account Manager, who Provides an ARDEC Interface to the Customer

Emerging Markets/Business Areas *(Quadrants II, III, IV)*

Established MDT

New MDT



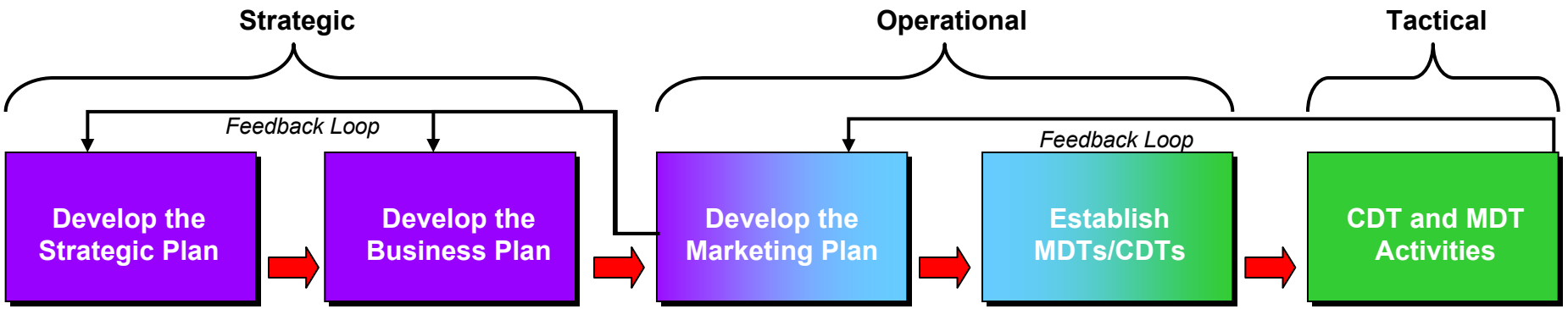
Supports ARDEC's Strategic Goals:

- Rapidly Provide Armament Technology Solutions
- Dominate the Armaments Market
- Be the Acknowledged Hub of Armament Core Competencies
- Attract and Retain a World-Class Workforce
- Reduce Base Operations Costs

Rationale for Selection:

- Direct Relationship to Army Needs and Capability Gaps Assessments
- Technical Scope is Definable and Manageable
- Demonstrates Future Growth Potential
- Strategically Important to ARDEC's Stakeholders
- Integrates Multiple ARDEC Competencies

ARDEC Strategic – Business – Marketing Process Flow



- Vision and Mission
- Strategic Objectives
- Strategic Approach
- Broad Competitive Analysis

- ARDEC Overview
- Key Success Factors
- Organizational and Management Descriptions
- Broad Marketing & Sales Assessment
- Product & Services
- Financial Outlook

- Independent Marketing Audit
- Interviews/Research
- Current Situation
- Identified and Prioritized Current and Potential Customer and Offering Lists
- Identified and Prioritized Campaigns with Funding Allocated
- Marketing Objectives and Forecast
- Contingency/Risk Plan

- Objectives
- Key Participants
- Target Customer(s)
- Anticipated Timeline to Achieve Results (MDT)

- Finalize Memberships
- Develop and Prosecute Campaign Plans
- Refine Customer(s) Target(s)
- Refine Target Technology to Bring to Customer(s)
- Develop and Present Capabilities Briefings
- Monitor, Track and Prioritize Opportunities
- Allocate Funding

* Color coded blocks highlight typical transition from pure strategic focus to pure tactical focus, note crucial ability of entities involved in operational planning to make the right link between strategic efforts and tactical efforts and ensure feedback and guidance flows effortlessly from one phase to the other

Business Development Process Benefits – Why Change?

- Drives Accountability and Coordination in Marketing
- Establishes Formal Processes for Business Development
- Allows Bid Decisions - “Ball Calls”
- All Business Opportunities Given Due Process
- Independent Evaluations of Proposals
- Creates a Formal Repository for Lessons Learned
- Eliminates Internal Competition
- More Efficient Resource Utilization
- Better Time Management
- More Responsive to Customer Needs
- Improved Communications
- ***Enables a Pro-active Organization***

Business Development Process……Home Base

- ARDEC has Established a Business Interface Office to Coordinate all Business Development Activities in One Location
- Business Interface Office Mission
  - Ensure Customer Satisfaction
  - Align ARDEC Strategic Plan and Corporate Investments with Customer Focus and Goals
  - Create and Manage Relationships with Congress, Government Agencies, Industry and Academia
  - Execute the Business Development Process for New Business Areas and Program Initiation

Business Interface Office: Elements

- **Business Development (Business Area Managers)**
  - New/Emerging Technologies (e.g. Armed Unmanned Vehicles, Prototyping, Homeland Defense, Nanotechnologies)
  - Tech Base Programs (ATOs, ACTDs, ATDs, MANTECH)
  - Small Business Innovative Research (SBIR) Program
  - International Programs (DEAs/IEAs, S&E Exchange Program, Cooperative Projects, Foreign Comparative Testing, DCAPs)
- **Asset and Technology Capitalization**
  - Technology Transfer (CRADA, Test Services)
  - Real Estate Usage and Industry Partnering
- **Customer Account Managers**
  - Customer Advocates that Manage Program Initiation and Provide Strategic Planning, Problem Solving and Project Support
- **Strategic Communications and Marketing**
  - Off-Site Personnel who Act in Specific Roles in Support of Customers or as Picatinny Liaisons
  - Direct Strategic and Corporate Marketing (Symposiums, Exhibits, VIP Visits)
  - Execution of the ARDEC Strategic Communications Program

Business Development Process & BIO Contacts

- Business Development Process Tiger Team Leader – Dave Burkhardt, Director, Strategic Communications, Phone 973-724-3510, E-mail dburkhar@pica.army.mil
- Business Development Process Owner – Joe Brescia, Chief, Business Interface Office, Phone 973-724-2326, E-mail jbrescia@pica.army.mil
- Business Development Manager – Andy Perich, Business Interface Office, Phone 973-724-3175, E-mail aperich@pica.army.mil
- Customer Account Manager Lead – Jim Zoll, Business Interface Office, Phone 973-724-6917, E-mail jzoll@pica.army.mil
- Asset and Technology Capitalization – Dave Banashefski, Business Interface Office, Phone 973-724-4369, E-mail dbanashe@pica.army.mil

BAE SYSTEMS

Precision Guided Miniature Munitions

Navigation and Guidance Concepts

40th Annual Guns-Ammunition-Rockets-Missiles Conference

Session 6, Mortars and Artillery

April 28, 2005

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Mission Need

- ***Provide small unit of operations with organic Precision Strike capability against High Value Targets***
- ***Accelerate Enemy Defeat***
- ***Reduce Collateral Damage***
- ***Improve Deployability & Logistics***
- ***RF Guided Muntion (RFGM)***
  - ***Provide a low cost precision means for ground forces to engage C3 targets, enemy FOs, and some radars***
  - ***Completes the sensor-to-shooter chain for IO targets operating from 30MHz to 3GHz***
- ***Optically Designated Attack Munition (ODAM)***
  - ***Ground or air laser designation of high value targets***
  - ***Covert Programmable Optical Tag***

Current Mortar Munitions have <0.1%. first shot direct hit on target. RFGM and ODAM guidance system capable of correcting trajectory improves first-shot hit on the target to 90%.

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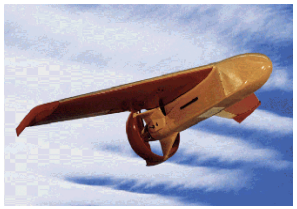
G&C Legacy

AN/ALQ-214
IDECM

APKWS 2.75
Rocket

Precision Guided Mortar
Munitions (PGMM)

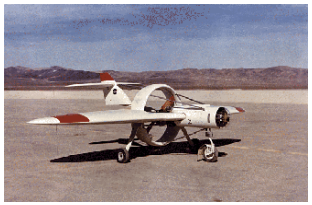
SKYEYE® R4E-50



SKYEYE® R4D

VTOL OAV

9” MAV



OBLIQUE WING

MINI SNIFFER

EAGLE ARV

QF-4 Drone

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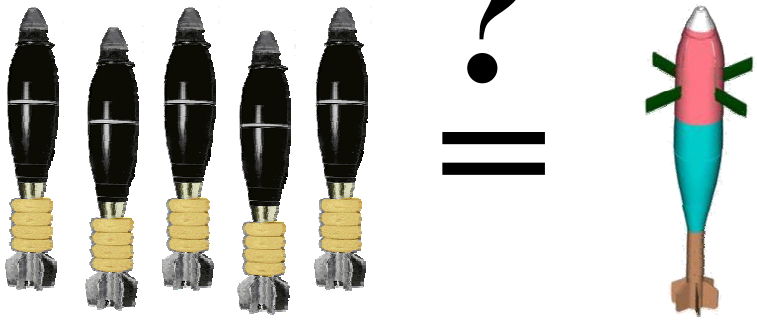
What is RFGM?

- ***Replacement fuze/guidance package that effectively converts current, ballistic 81 mm mortar munitions into precision RF guided munitions***
- ***Screw-on mod-kit***
- ***Affordable, Easy to use***
- ***Frequency range 30MHz to 3GHz***
- ***Accuracy not dependent on visual observation***
- ***Fire and Forget***
- ***First shot kill***
- ***Passive, all-weather***
- ***Technology that is scalable to other munitions***



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RF Guided Munitions

Technical Challenges

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Launch Cue → **Geo-locate** → **Maneuver toward target** → **Detonation**

- Initial detection, discrimination and geolocation
- Leverage technology developed in Wolfpack/MANPACK

<20m accuracy (CEP) with << 0.3λ aperture

- ≥ 0.5g capability and stable control
- Not accomplished for this size munition;
- Leverage PGMM/BAT

3m Airburst using GOTS proximity fuze

System Integration

- Miniaturize to a 81mm mortar round
- Cost effective
- Match maneuver, target, and munitions capability

Existing technology | Extension of existing technology | Seedling analysis indicates feasible

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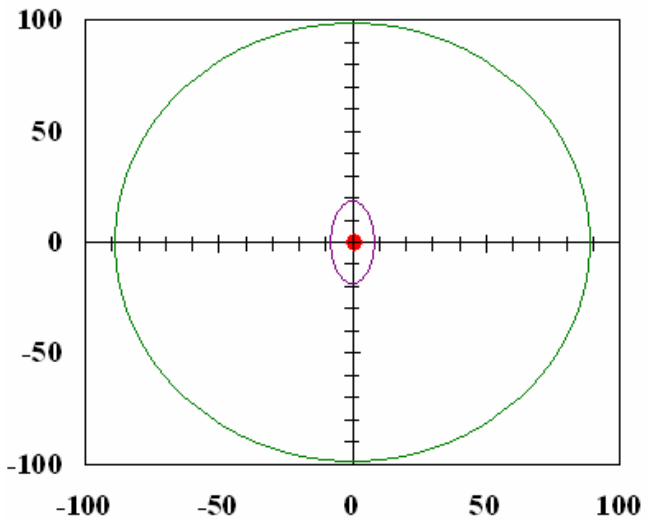
What is ODAM?

- ***Replacement fuze/guidance package that effectively converts current, ballistic 60 mm mortar munitions into optically designated 60 mm attack munitions***
- ***Rapid path to an affordable (<$300/unit) manufacturable end product.***
- ***No megapixel steering array***
- ***No cooled detectors***
- ***Visible light tag for daytime***
- ***Optimize for: Rugged, simple, and cheap***



CEP (meters) for 60 mm mortars

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Precision Guided Miniature Munitions

Seeker Types – System Integration

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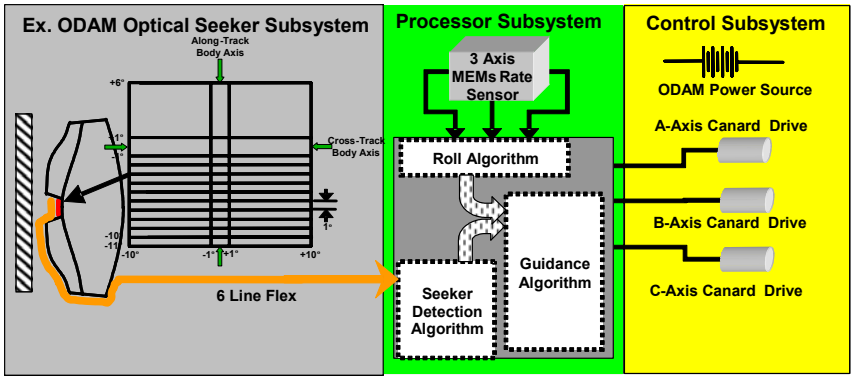
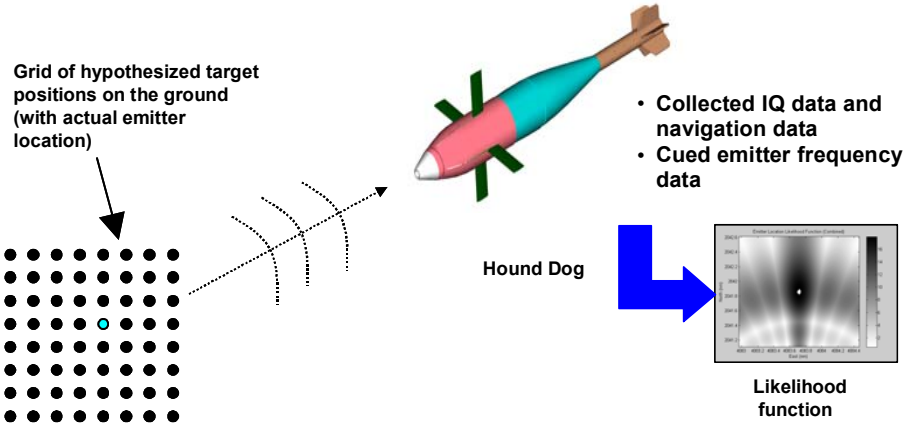
Seeker type strongly impacts system design.

- **Sensor integration must be considered when designing guidance and control system ⇒ including CAS design and aero-mechanical integration**

ODAM
High Resolution Optical Array Seeker

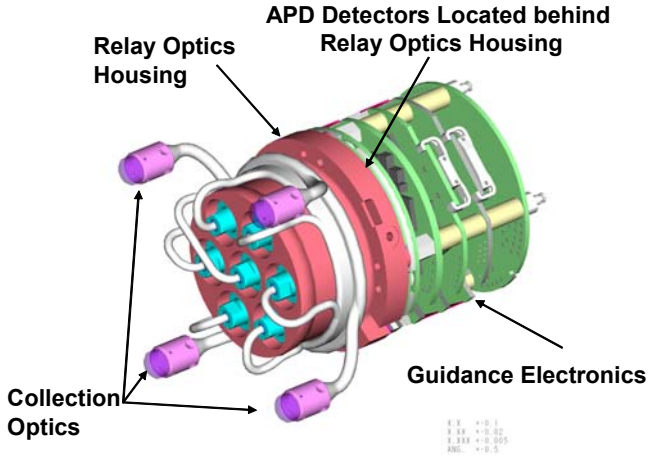


RFGM
High Resolution RF Antenna Array Seeker



Hound Dog method uses both phase and amplitude information from all the antenna elements and then determines emitter geolocation metric by computing the probability likelihood surface of the potential emitter location as a function of its hypothesized location.

APKWS
Distributed Semi Active Laser Seeker



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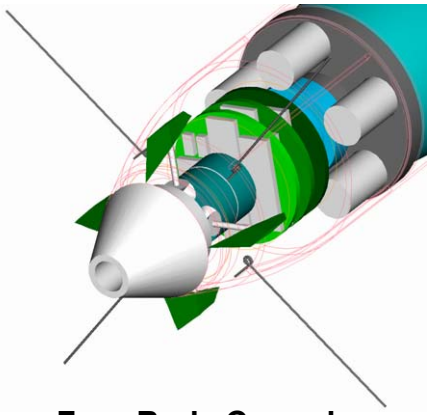
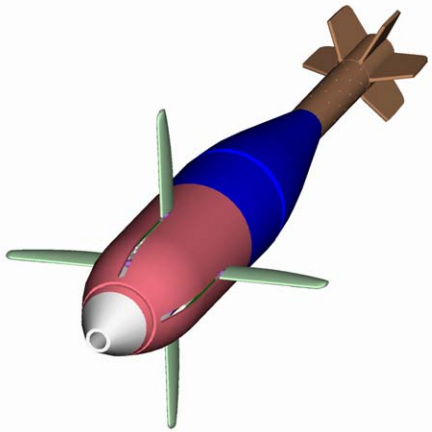
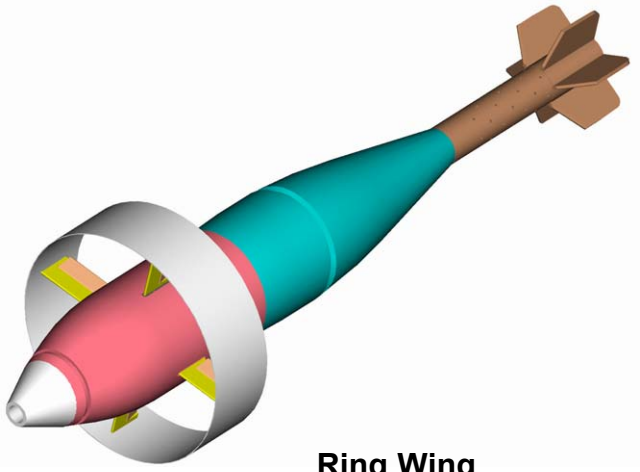
Aerodynamics



Fore-Body Canards



Mid-body Wings



Ring Wing

Two distinctly different aerodynamic design concepts were evaluated to determine basic feasibility of aero-mechanical implementation.

Concept type 1: Mid-body guidance. Approach using Mid-body wing surfaces to generate added normal force and provide steering.

Concept type 2: Fore-body guidance. Moment approach using canards mounted forward to generate normal force and controlled pitch moment effecting steering.

Each method is considered at the integrated system level versus specific design criteria.

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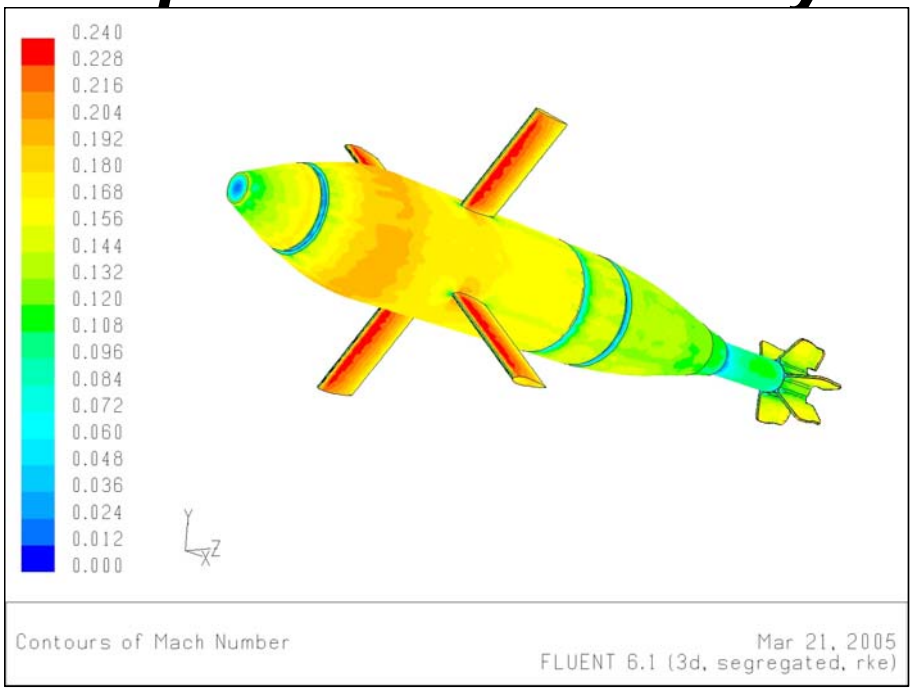
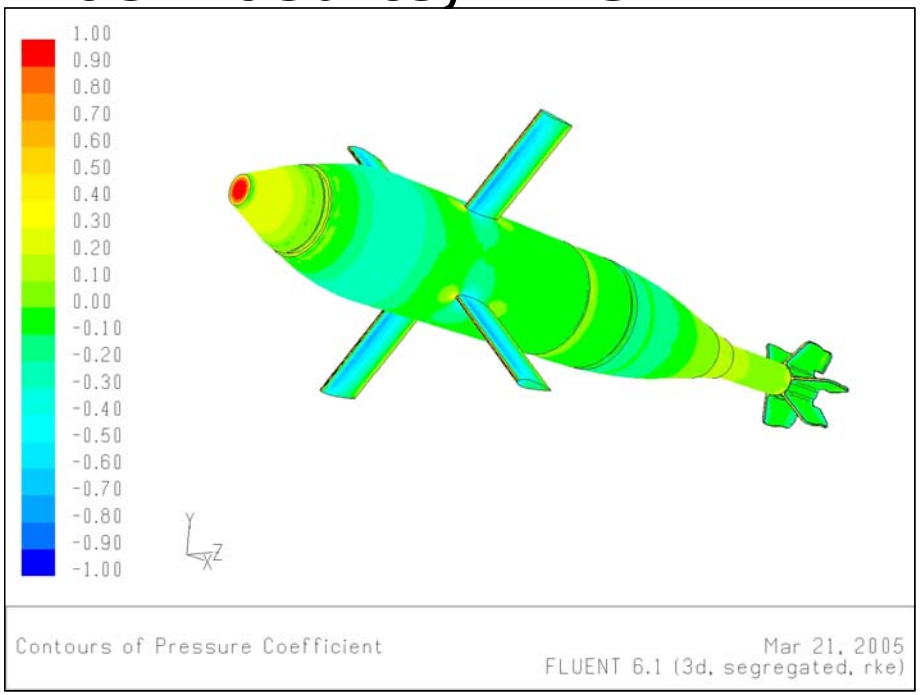
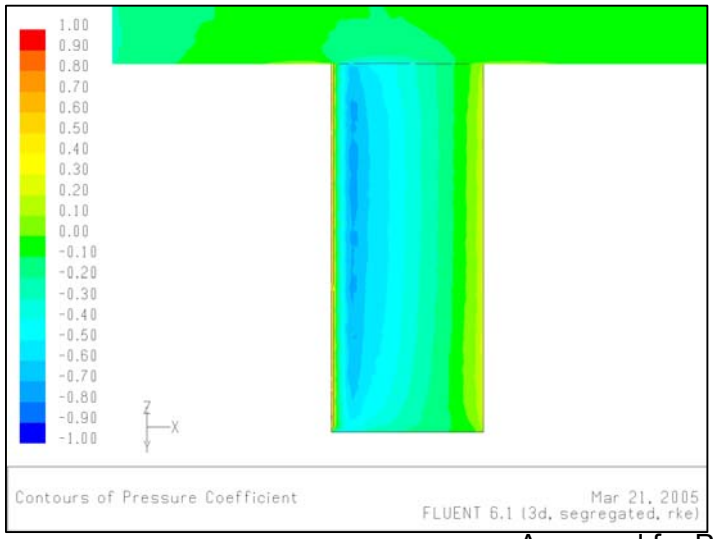
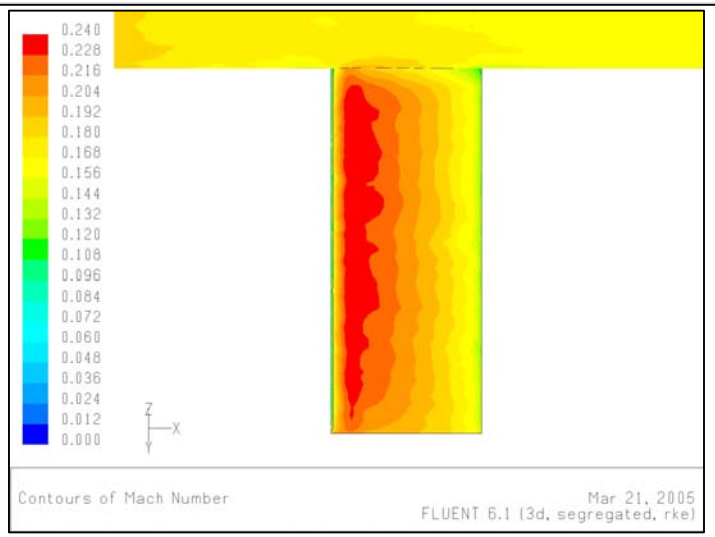
Computational Fluid Dynamics Results, RFGM







Pressure and Mach Contours on Wing



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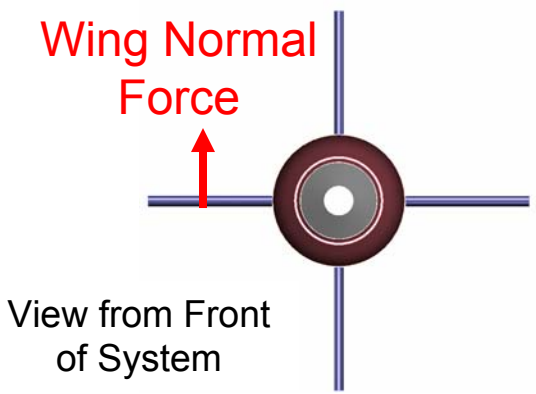
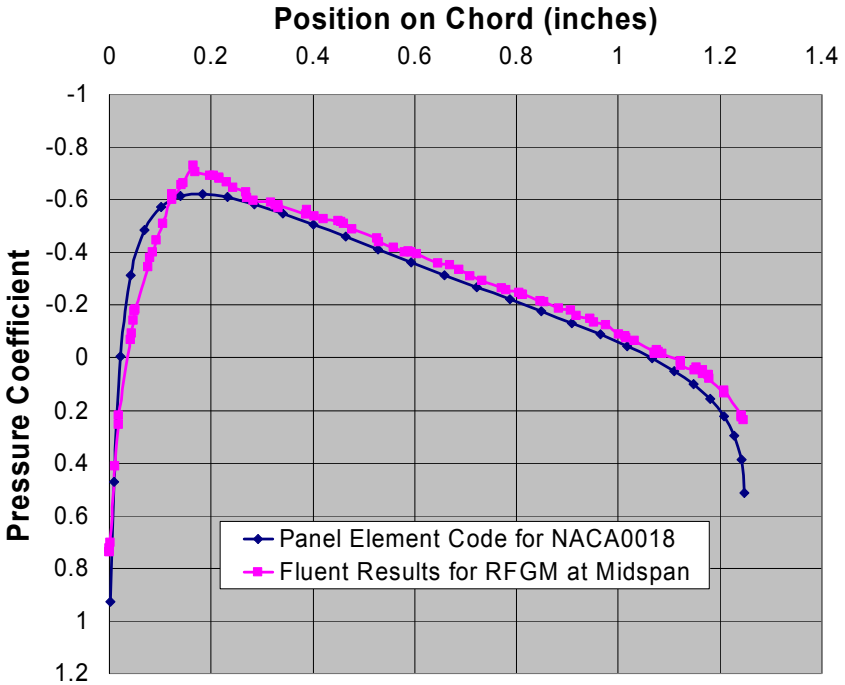
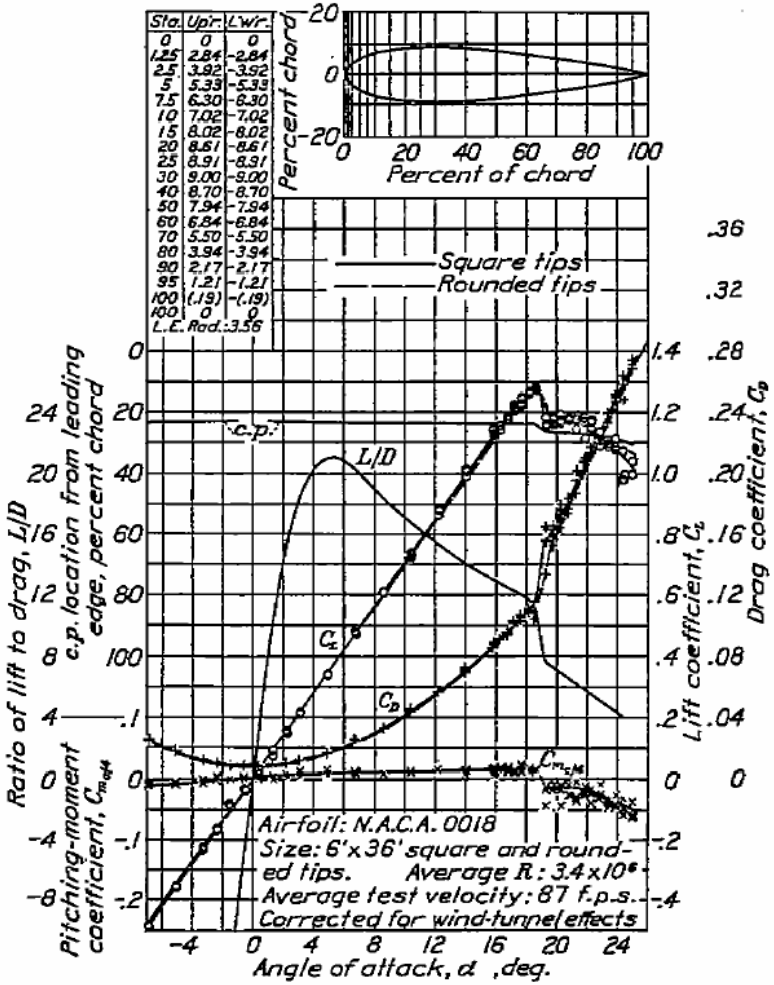
Aerodynamic Calculations – RFGM mid body wings







"Tests of N.A.C.A. 0009, 0012, and 0018 Airfoils in the Full-Scale Tunnel" NACA Report No 647

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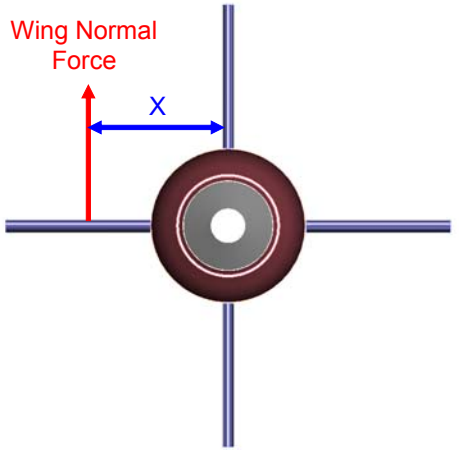
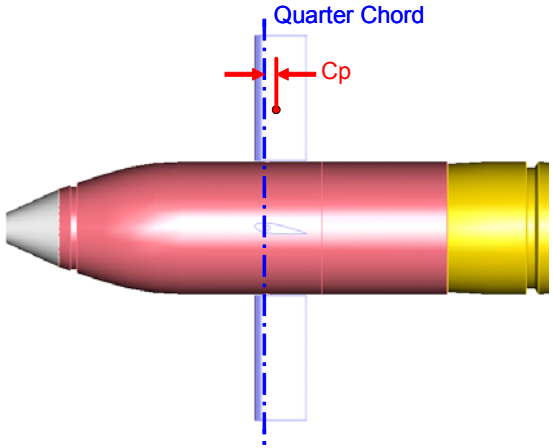
Computational Fluid Dynamics Results, RFGM

Results are utilized in 6 DOF modeling of performance as well as structural design

X (inches from centerline)		Mach	
		0.2	0.6
Wing AoA	3°	3.13	3.02
	10°	3.27	3.08



Cp (inches from quarter chord)		Mach	
		0.2	0.6
Wing AoA	3°	0.023	0.063
	10°	0.026	0.084



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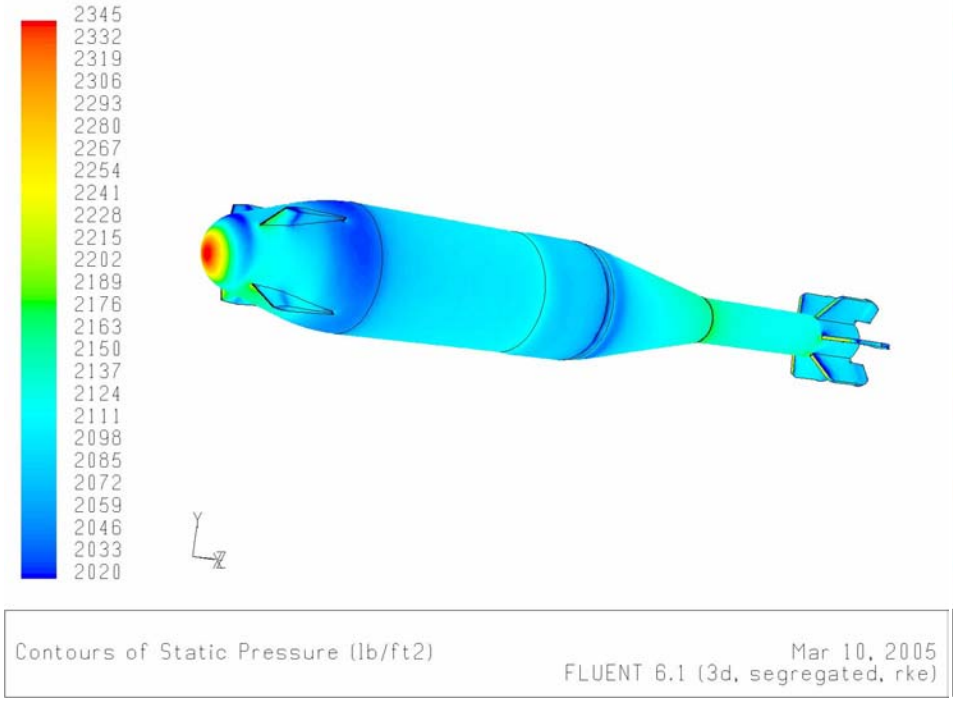
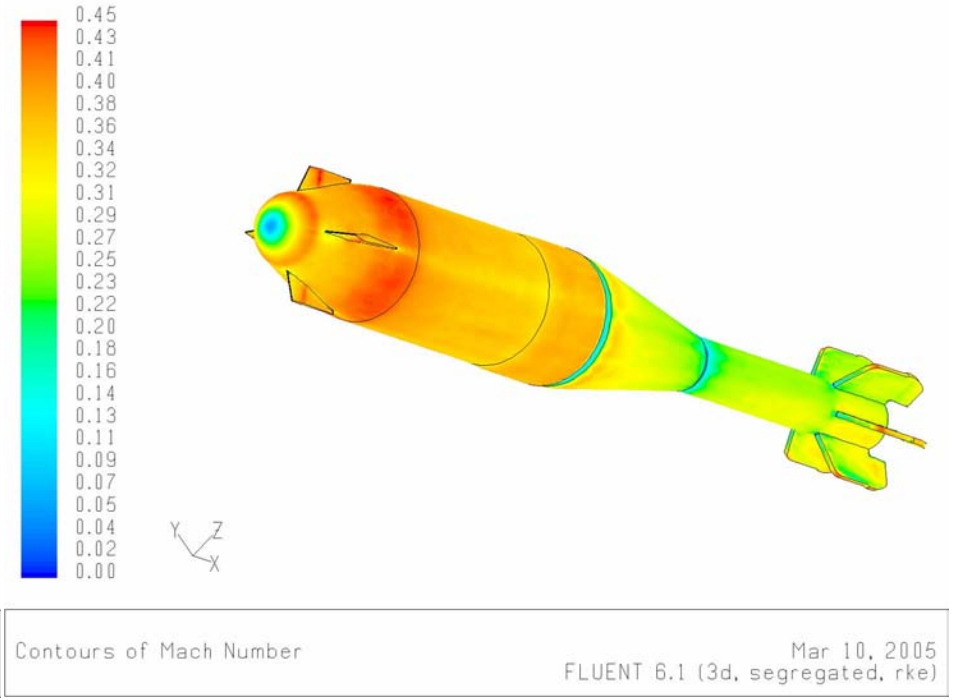
Computational Fluid Dynamics Results, ODAM





Pressure and Mach Contours on ODAM Projectile with canards installed and under various flight conditions. Data extracted is utilized for canard sizing to achieve required maneuverability, structural design of canard surfaces, guidance and control system development.

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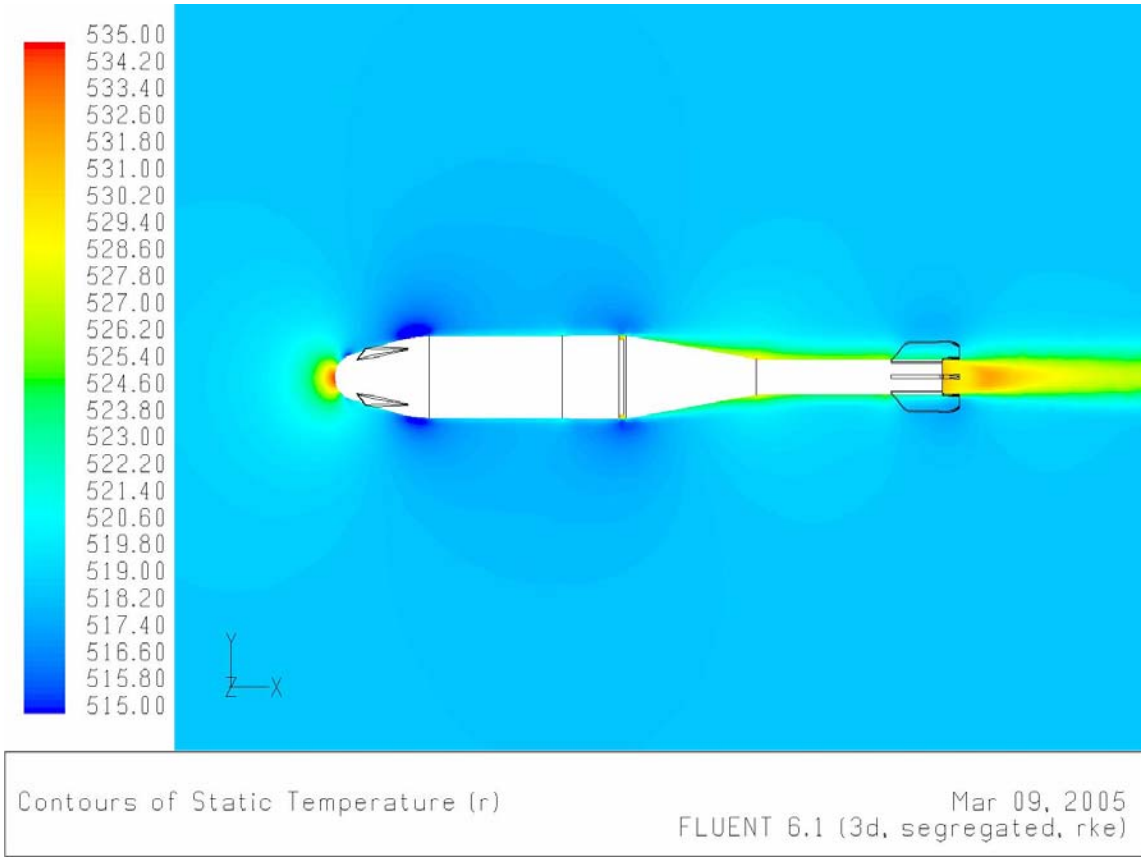
Aerodynamic Calculations – Temperature



- **CFD has proven extremely useful in computation of other related aerodynamic phenomena of interest to ODAM development**
  - **A thorough understanding of thermal heating of optical window on nose is required for seeker performance**

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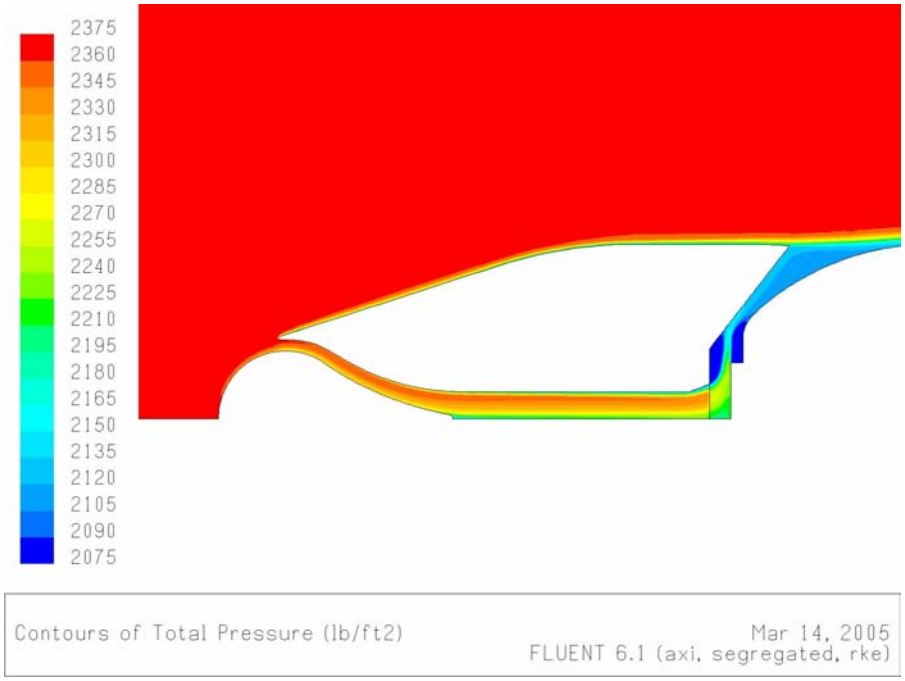
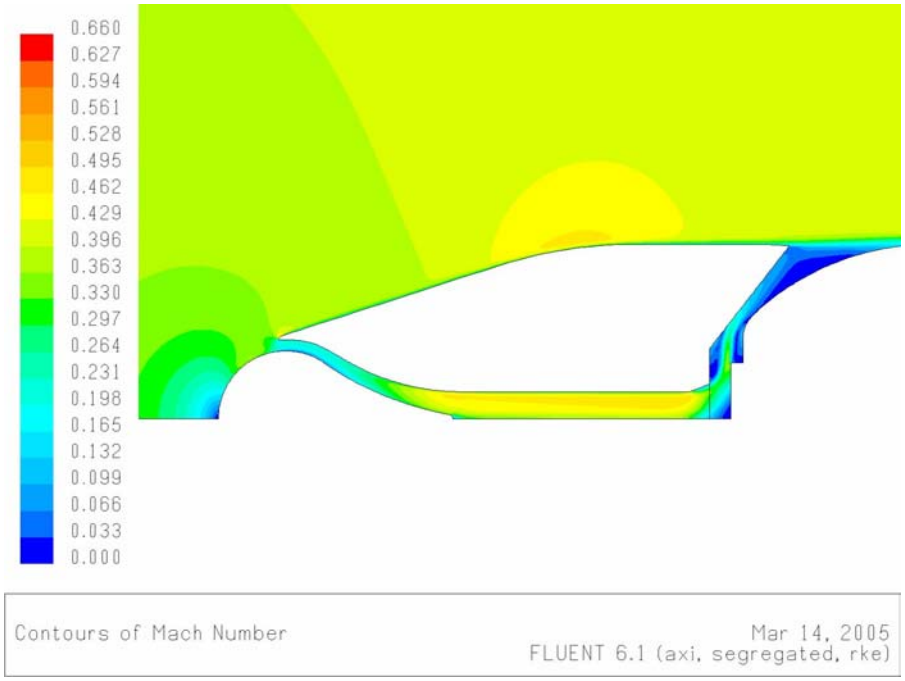
Computational Fluid Dynamics Results, ODAM





- **CFD has been utilized in computation of inlet performance during design phase in order to ensure integration of critical fuze components is properly accounted for.**

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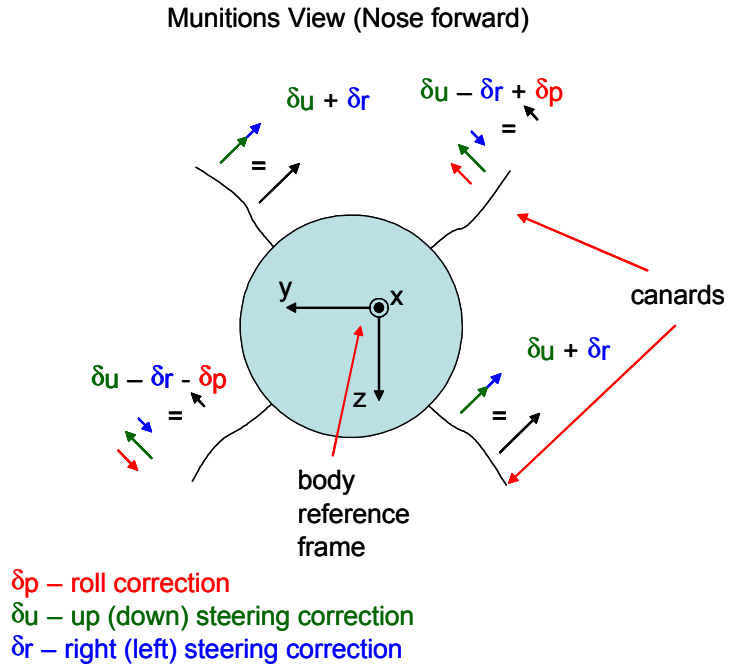
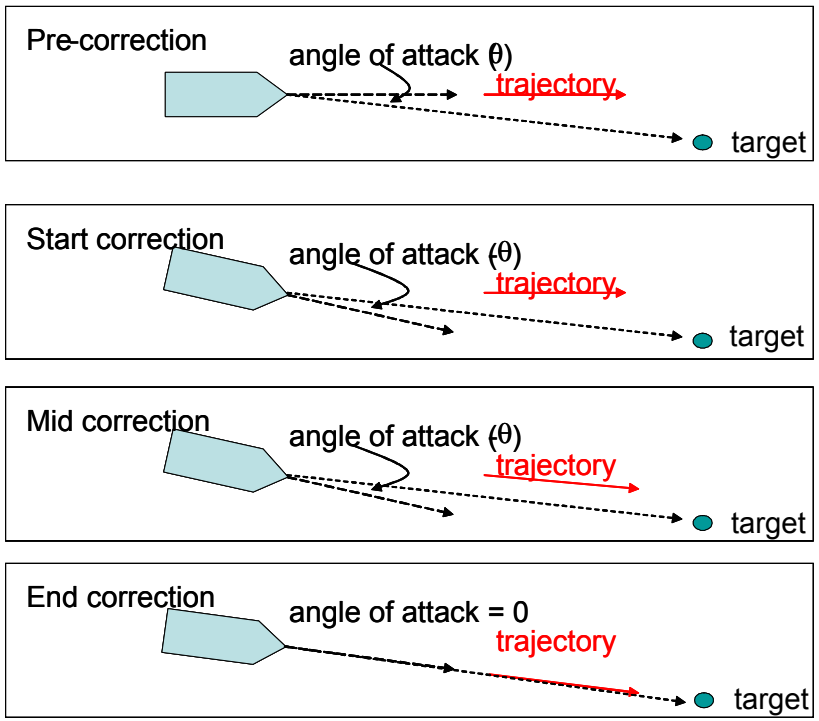
CAS - Command Requirements

- Tied directly to aerodynamic performance requirements
- Spin control requires differential mode
  - Drive $\varphi_B \rightarrow 0$
- Pitch control requires common deflection
  - Maximize F_N in direction of target
- Control surfaces are torque balanced.
  - I.e.: Hinge located @ wing $C_P \rightarrow$ minimizes motor torque requirements





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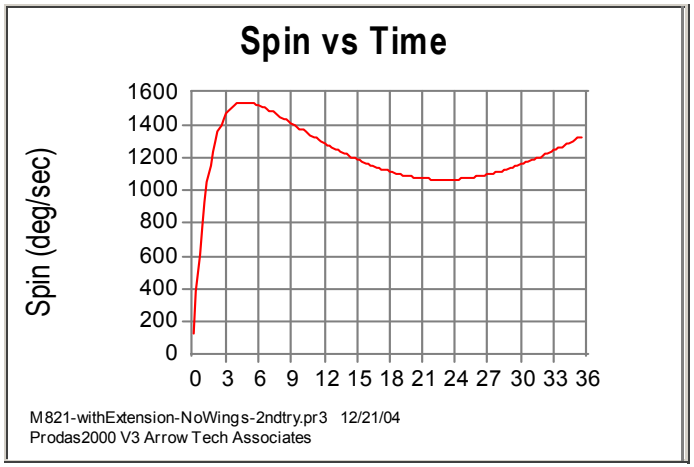
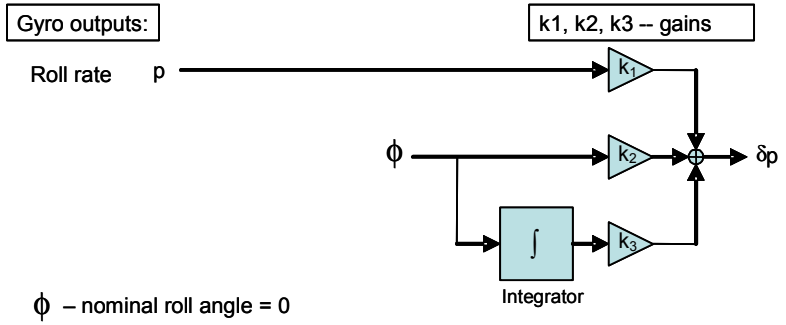
CAS Requirements

- Control roll & pitch of projectile
- Integrate steering commands with aerodynamic control surfaces
- Both RFGM and ODAM projectiles constantly spin
  - Spin generated via 5° tail fin cant
    - Fosters requirement to despin and maintain despun orientation throughout flyout and while maneuvering to target.
      - Complicates guidance process
      - CAS must despin, maintain specific orientation, and maneuver simultaneously
- CAS must exert fine grain control of aerodynamic surfaces to prevent over control



PID Controller



ϕ – nominal roll angle = 0

p – roll rate

δp – control input to canard

- Zero roll is maintained by using a Proportional-Integral-Derivative (PID) control loop.
- The "proportional" and "integral" inputs come from the pitch and yaw rate gyros.
- The "derivative" term comes from the roll rate gyro. These three terms are combined to estimate the instantaneous roll rate component and steer the canards appropriately to offset this effect

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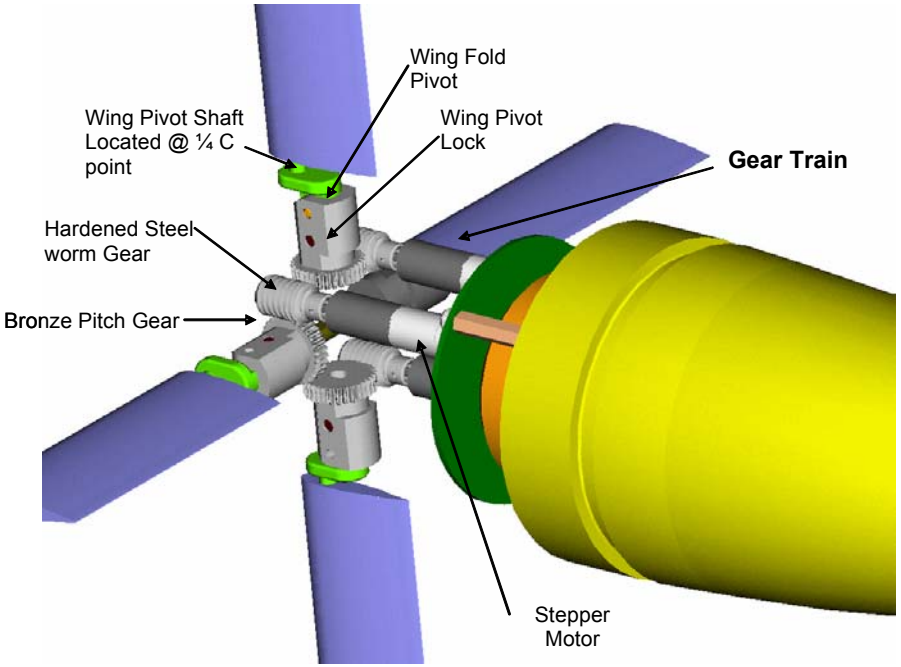
CAS – Motor / Control Options

- Several potential motor / drive options are available ranging from 1 to 4 motors.
  - Trade study initiated to down select to preferred option
- 3 Motor → RFGM / ODAM ⇒ Selected for Phase 1configuration
  - 1 common axel (pure pitch)
  - 2 Independent axels (roll & pitch)
- 4 Motor
  - Each supports both roll & pitch
- 2 Motor
  - Requires $1_{in} \rightarrow 2_{out}$ transmission (prototype of simplified version developed with $1_{in} \rightarrow 4_{out}$ and limited testing performed)
- 1 Motor
  - Requires higher complexity transmission with shaft independent shifting function
    - Variant of $1_{in} \rightarrow 4_{out}$ previously developed with addition of complex shifting function added

RFGM CAS Design
Antennas integrated within wing



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Summary

- Precision Guidance of Miniature Munitions is viable.
  - RFGM ⇒ 81 mm round incorporates mid-body wings
  - ODAM ⇒ 60 mm round incorporates fore body canards
- Aerodynamics are readily calculated using current CFD techniques
  - Well understood force, moment, and damping is required in order to design guidance system
    - Some aspects are complex and require more than traditional level of design treatment ⇒ spin terms such as Magnus force and moment along with coupled aerodynamics parameters
- Advances in miniature, affordable sensors such as the IMU incorporated into RFGM provide enabling technology for solution of complex guidance and control problem
- Guidance and Control must be highly integrated with seeker / sensors in order to provide best system level solution

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Questions?

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Points of Contact

RFGM:

DARPA – Dr. John Allen

jallen@darpa.mil

ODAM:

DARPA – Dr. Douglas Kirkpatrick

dkirkpatrick@darpa.mil

BAE Systems – Mr. Dan Bradford

daniel.bradford@baesystems.com

Phone 603-885-5937

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ATK

An advanced weapon and space systems company

Defining Homogeneity for Medium Caliber Ammunition and Small Grain Propellant Lots

Scott Carney
30mm Ammunition Product Engineer

April 28, 2005

Background

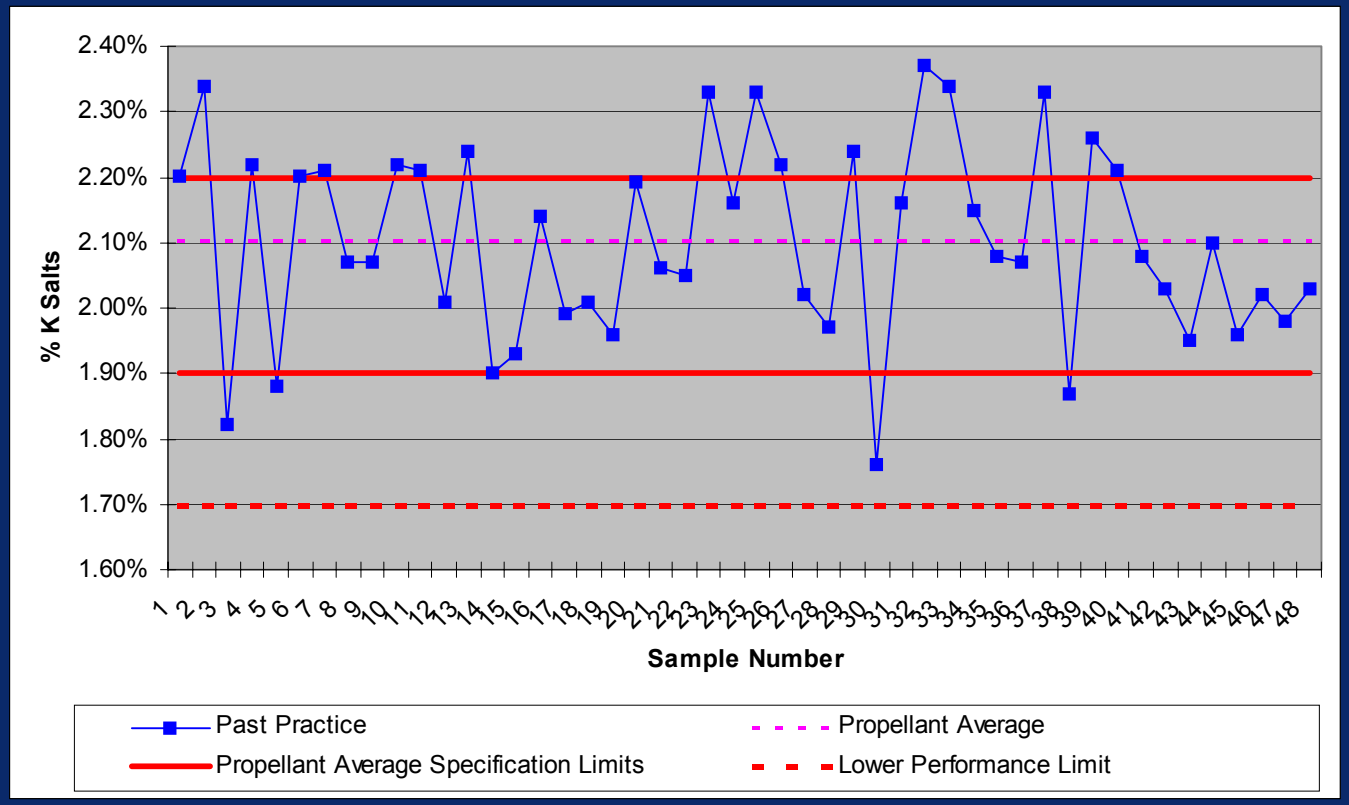
- **30mm GAU-8/A gun system requires potassium (K) salts to prevent secondary gun gas ignition (SGGI) at the muzzle**
  - 1.7% K salts minimum required in each cartridge (lower performance limit)

- **Propellant requirements**
  - 1.90% to 2.20% K salts
  - Specification allowed averaging of samples to determine final value
  - Homogeneity requirement poorly defined

- **Use distribution of flash suppressant (FS) grains to determine homogeneity**
  - Propellant contains ~3% by weight of FS grains to adjust K salts

Past Practices

- **Baseline determined prior to beginning investigation**
  - 3 x 30 g samples pulled every 5000 lb.
  - Analyzed by Atomic Absorption Spectroscopy (AAS)
  - Average = 2.10% K salts (SD = 0.15%)
  - Relative SD = 7.1%



Historical Ambiguity of Homogeneity

- **Webster's Dictionary**
  - "Of the same or a similar kind."

- **MIL-STD-1168B for Ammunition Lot Numbering and Ammunition Data Card**
  - "When all units of product in an ammunition lot have been produced by one manufacturer, in one unchanged process, under stable conditions of production, in accordance with the same drawings, the same specifications and any revisions thereto, a 'state of homogeneity' shall exist."

- **30mm propellant specification DS 8560**
  - "The procedure utilized for the blending of propellant, sublots and/or batches to form a lot shall result in a homogeneous mixture."

A new quantitative and qualitative definition of homogeneity is needed

Proposed Definition of Homogeneity

- **ATK and Hill Air Force Base (HAFB) teamed to write a new definition**
  - "The procedure utilized for the blending of propellant sublots and/or batches to form a lot shall be such that random samples have the same characteristics as the entire lot. "

- **With the qualitative definition completed, unanswered questions remained for the quantitative definition**
  - What is the ideal sample size?
  - What analytical method would be used?
  - How would the sample be obtained?
  - How many samples will be needed?

Find a model to measure homogeneity

Basis for Homogeneity Parameters

- **ATK retained the services of Jenike & Johanson (J & J)**
  - A bulk solids flow engineering consulting firm
  - Extensive background in blending
  - Pharmaceutical industry experience
  - Involved in Federal Court case to define homogeneity

- **FDA definition utilized as starting point**
  - FDA: Finished product at USP I stage testing
    - Sample 30 units and test 10 (N = 10)
    - Limits
      - Mean within 90-110%
      - Relative standard deviation (RSD = σ/avg.) ≤ 6%
      - All individual results are within range of 85 to 115% of label claim

FDA requirement is tighter than past practice

Determining a Sufficient Sample Size

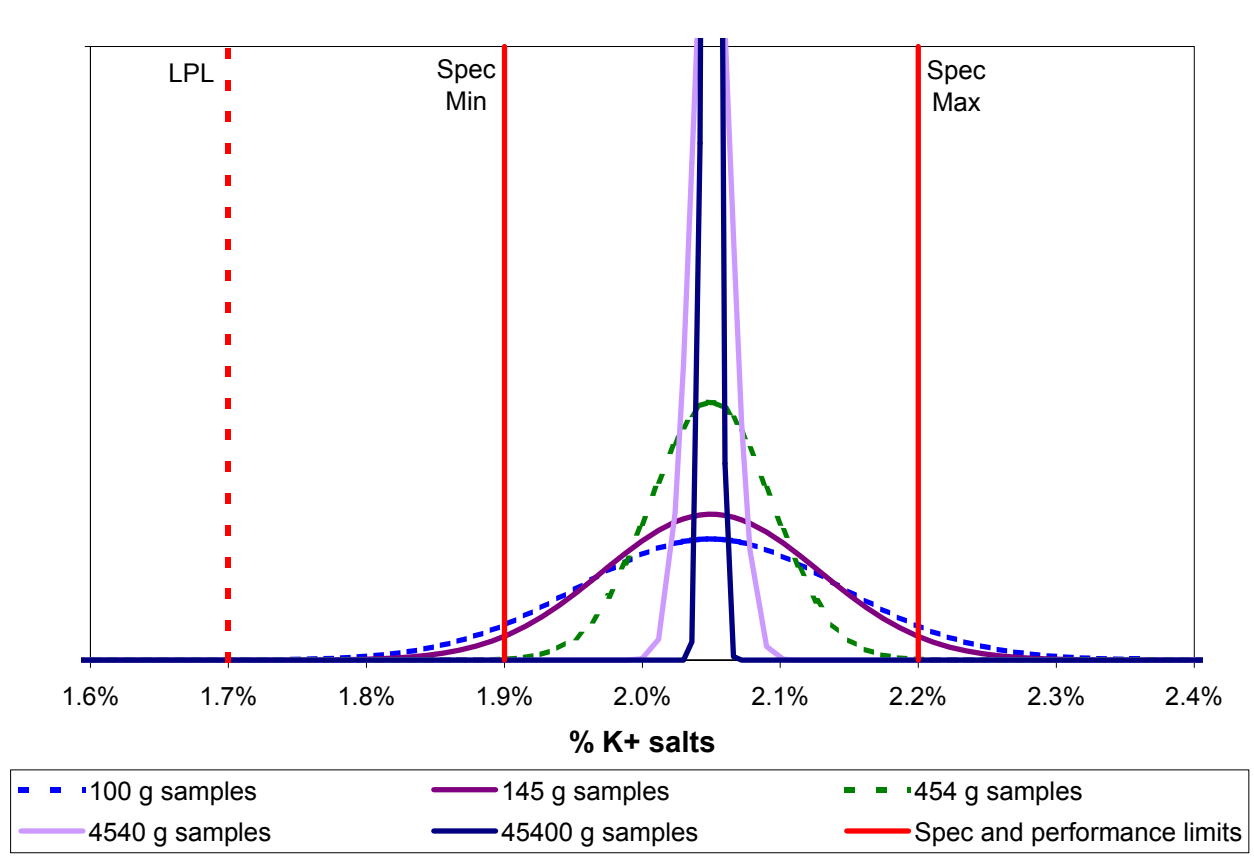
- **Sample size effects analytical results**
  - The smaller the sample size, the greater the effect of each FS grain

Total K Salts	Number of FS Grains in Sample (g)						
	10	50	100	145	454	4540	45400
2.25%	31.8	159.1	318.2	461.4	1444.6	14446.2	144461.6
2.20%	31.0	154.8	309.6	448.9	1405.6	14055.7	140557.3
2.05%	28.4	141.9	283.8	411.5	1288.4	12884.4	128844.2
1.90%	25.8	129.0	258.0	374.1	1171.3	11713.1	117131.1
1.85%	24.9	124.7	249.4	361.6	1132.3	11322.7	113226.7

Need to determine the ideal sample size that meets the requirements

Ideal Sample Size

- **Theoretical calculation to predict the distribution of K salts for a statistically homogeneous mixture**



A 1 lb. sample meets the requirements

Quantitative Analysis of Propellant Samples

- **Past practice was to use AAS for potassium salt analysis**
  - Two issues identified
    1. Presence of FS grains increased SD
    2. Sample size is limited – 50 gram max

Sample Size	FS Present	Number of Samples	Average (%)	Minimum (%)	Maximum (%)	SD
10 g	No	9	0.42	0.41	0.45	0.01
10 g	Yes	9	2.13	1.61	2.47	0.23
50 g	Yes	5	2.10	1.82	2.32	0.19

An improved analytical method is needed

Low-Tech Can be Better than High-Tech

- **FS grains contain potassium – an alkali metal**
  - FS grains ”light up” when exposed to x-ray
  - Positives
    - High reliability and repeatability – 99%
    - Sample size up to 150 g
  - Negatives
    - FS weight is estimated during calculations
    - Spreading sample into a mono-layer

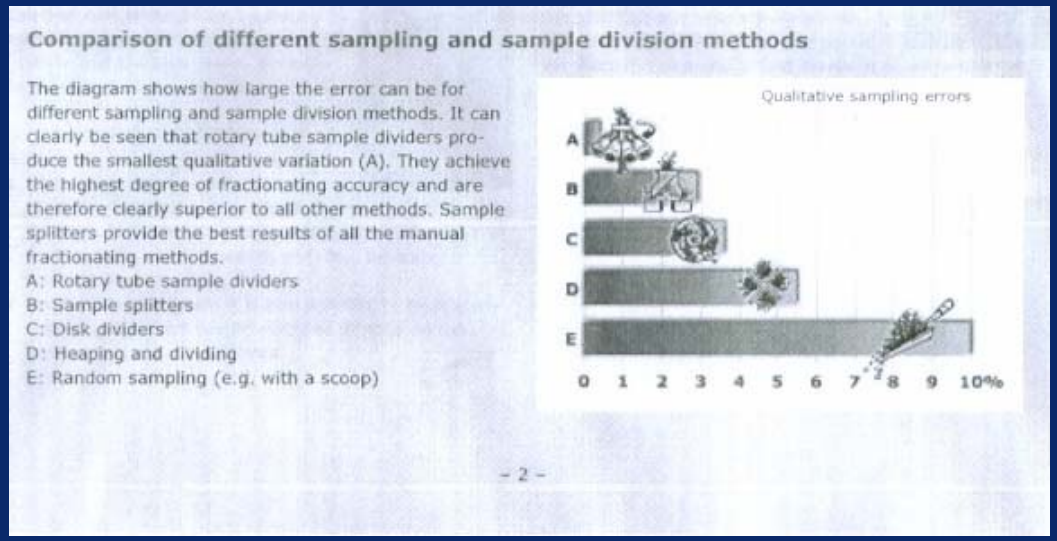
- **Desire a method to determine actual weight of components**
  - Solvent system of a density to separate FS grains from propellant grains
  - Components can be dried and weighed

Density separation analytical method is most desirable

Sampling is as Important as the Analysis

- **J & J stressed the importance sampling on the final results**
  - Past practice was to sample using a scoop (highest error)

- **Now all samples are obtained with a sample splitter and rotary riffler**
  - Sample splitter can handle drum-size quantities
  - Rotary riffler divides sample into 8 sub-samples



Comparison of different sampling and sample division methods

The diagram shows how large the error can be for different sampling and sample division methods. It can clearly be seen that rotary tube sample dividers produce the smallest qualitative variation (A). They achieve the highest degree of fractionating accuracy and are therefore clearly superior to all other methods. Sample splitters provide the best results of all the manual fractionating methods.

A: Rotary tube sample dividers
B: Sample splitters
C: Disk dividers
D: Heaping and dividing
E: Random sampling (e.g. with a scoop)

- 2 -

Proving Homogeneity Through Sampling

- **Past practice was to randomly select 5 drums from the propellant lot for acceptance testing per specification**
  - A propellant lot could consist of up to 1,500 drums
  - 50 drums of propellant are packed through each final blend cycle

- **Studies were conducted to prove the propellant is homogeneous within a blend cycle**
  - Randomly select a drum from each final blend cycle
  - Each drum sampled for analysis

The number of samples shall be the greater of 20 samples per lot or 1 sample per 5,000 lb. of propellant

Final Parameters for Measuring Homogeneity

- **The quantitative definition of homogeneity**
  - All acceptance samples to be obtained using a sampling device
  - Analysis to be conducted using x-ray or density separation analysis
  - Population limits added to ensure propellant is above 1.7% K salts

Criteria / Parameters	Sample Size (g)	Specification Range per Sample	Relative Standard Deviation	Maximum Population SD (%)	Population Limits for Lot		Number of Samples
					x(bar) - 3SD	x(bar) + 3SD	
% K Salt	454	1.9 - 2.2%	4.0	0.08	>1.8%	<2.3%	Greater of 20 per lot or 1 per 5000 lb.

In the end, the requirements for homogeneity are tighter for propellant than those required by the FDA for the pharmaceutical industry!

Results of Homogeneity Improvements

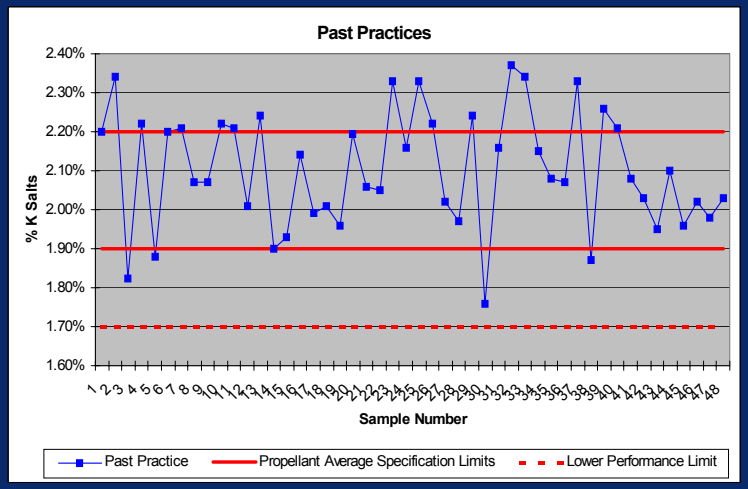
- **Implementation of process improvements have proven to be effective**
  - All propellant samples meet the specification
  - Customer confidence in propellant has increased
  - Muzzle SGGI has been reduced to desirable levels

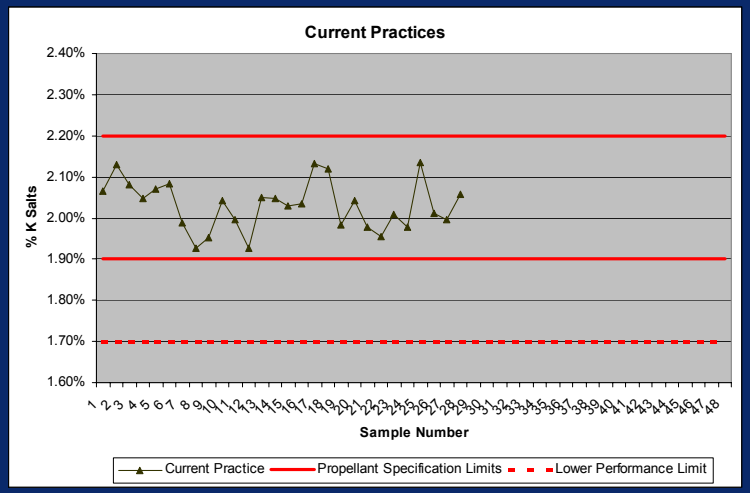
	Criteria / Parameters	Sample Size (g)	Range of Samples	Relative Standard Deviation	Maximum Population SD (%)	Population Limits for Lot x(bar) - 3SD	Population Limits for Lot x(bar) + 3SD	Number of Samples
Requirements	% K Salt	454	1.9 - 2.2%	4.0	0.08	>1.8%	<2.3%	Greater of 20 per lot or 1 per 5000 lb.
Results	Past Practice	30	1.76-2.37%	7.1	0.15	1.66%	2.55%	48
	Current Practice	454	1.93-2.13%	2.9	0.06	1.85%	2.21%	28

ATK has packed over 500,000 lb. of homogeneous propellant

Current Practices

- **An example of a current production lot**
  - 1 lb. sample pulled every 5000 lb.
  - Analyzed by x-ray
  - Average = 2.03% K salts (SD = 0.06%)





Variation reduced by more than 50%

Acknowledgements

Mr. Chris Hebertson, Hill Air Force Base
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Mr. Stephen Tutt, ATK Radford

United Defense

Advanced Gun Barrel Technologies
Program Status

Dr. Amir Chaboki

United Defense

NDIA Guns -Ammunition - Rockets - Missiles Conference
28 April 2005

NAVSEA DAHLGREN SURFACE WARFARE CENTER DIVISION

Large Caliber Naval Guns

MK 45 / Mod. 2
Bore: 5-inch (127mm)
Length: 54cal, 22.5 ft (6.9m)
Operating Pressure: 55 kpsi (380 MPa)
Range: 13 Nmi
Volume of Fire: 16-20 rnds/min (20 round ready service)
Barrel Life: 8000 rnds
Thermal Mgmt: Air Cooling
Mark 67 charge with various projectiles

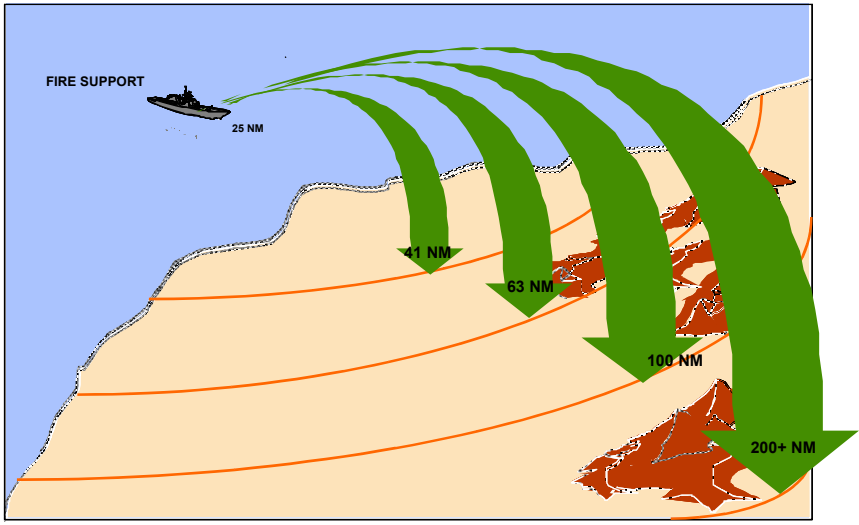
MK 45 / Mod. 4
Bore: 5-inch (127mm)
Length: 62cal, 25.8 ft (7.9m)
Operating Pressure: 63 kpsi (435 MPa)
Range: 63 Nmi
Volume of Fire: 90 @ 10 rnds/min
Barrel Life: 1,500 rnds
Thermal Mgmt: Air Cooling
ERGM Projectile/Propelling Charge

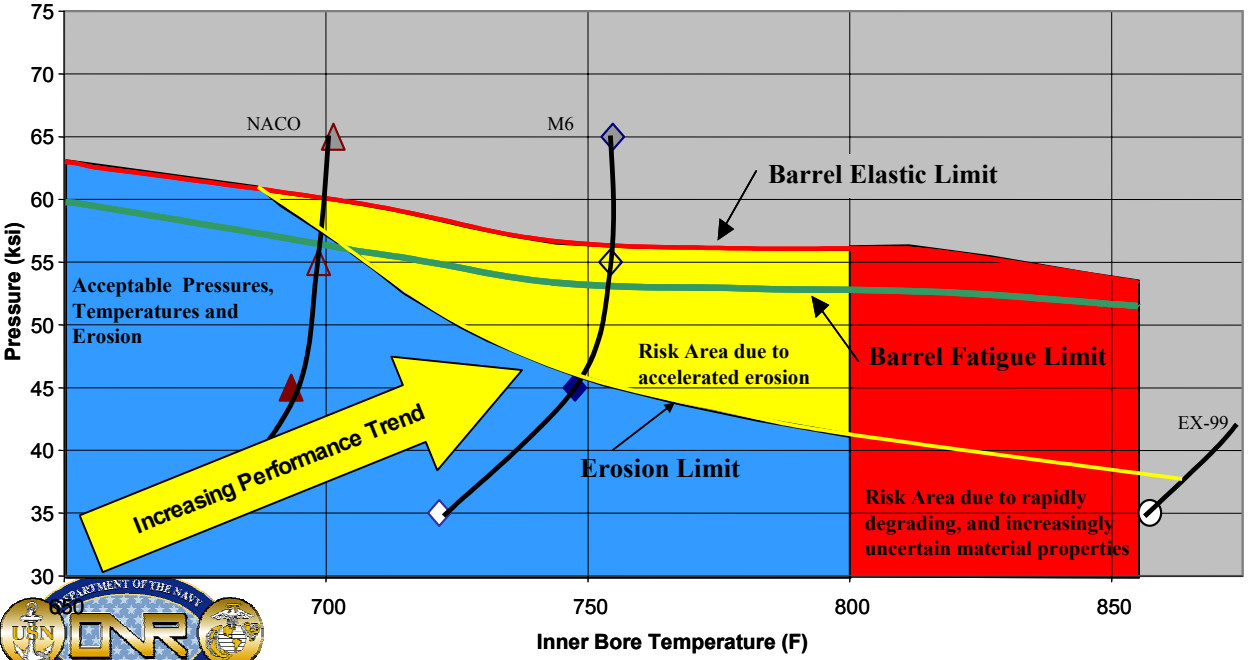
Advanced Gun System (AGS)*
Bore: 155mm (6.1 in)
Length: 62cal, 31.5 ft (9.6m)
Operating Pressure: 53 kpsi (365 MPa)
Range: XX Nmi
Volume of Fire: 10 rnds/min Continuous
Barrel Life: 3,000 rnds (Est.)
Thermal Mgmt: Liquid Cooling
Long Range Land Attack Projectile/Propelling Charge
*Currently Under Development

Increased performance levels result in barrel life becoming a logistics cost driver

Limitations of Current Barrel Technology

- The trend of gun performance requirements has been for increased range and rate of fire for centuries
- Wear and thermal management limit system performance
- Highest energy propelling charge and advanced projectile solutions are precluded by barrel limitations
- Improving wear, erosion or thermal management yields increased system performance





- Barrel Design Space Limits
  - Elastic strength
  - Fatigue strength
  - Max bore temperature
  - Wear and erosion

Advanced Gun Barrel Technologies

Future Naval Capabilities Program

Objectives

- Identify & develop Gun Barrel Technologies that enable upgrades to existing barrel capabilities for Naval gun propulsion missions
  - *Increased Gun Barrel Erosion & Fatigue Life*
  - *Improved Gun Barrel Thermal and Ballistic Performance*
  - *Reduced Life Cycle Cost*

Payoffs

- Increased Gun System Availability
- Improved Ballistic Capability (Higher KE for increased range)
- Lower Life Cycle Cost

Transition

- Develop/Demonstrate Improved Barrel Life and Ballistic performance over AGS Baseline for Transition into Future DD(X) Flights

Advanced Gun Barrel Technologies Plan

Develop Two Advanced Barrel Technologies Concurrently

1- Refractory / Steel Barrel : Focus on the technologies providing longer barrel erosion and fatigue life.

- Develop and apply alternate coating / liner material and processing to the existing Chromium plating.

2- Composite Barrel : Develop Composite gun Barrel for improved thermal management and wider design space for enhanced ballistic performance for current and future gun barrels

- Technologies such as Metal Matrix Composites that provide more flexibility in achieving desired material properties in radial and axial directions in the barrel

Each technology path will provide increased barrel life and if both successful, will be combined for substantial barrel life improvement

Advanced Gun Barrel Technologies FNC

Technical Approach

Refractory Lined / Coated Steel Barrel

FY03	FY04	FY05	FY06	FY07
TECHNOLOGY SELECTION	MEDIUM CALIBER COMPETITION	AGS 155-mm PROTOTYPE DESIGN & FAB		AGS GUN DEMONSTRATION

Trades / Screening Tests

- Magnetron Sputtering
- Solid Free Form Fab
- Explosive Cladding
- Others

→ Extended Barrel Life Competition in Small Caliber Barrel (76-mm)

→ Downselect Technology for AGS Application
- Develop AGS Design
- Fab AGS 155-mm Barrel

→
- Barrel Proof Out
- AGS Gun Demonstration
- Qualification / Transition

Potential Liner / Coating Technology Insertion Point

Advanced Composite Barrel

FY03	FY04	FY05	FY06	FY07
INTERFACE TECHNOLOGY	COMPONENT DESIGN/VALIDATION	COMPOSITE GUN BARREL DESIGN	FABRICATE COMPOSITE BARREL	DEMONSTRATION TESTING

System Level/Concept Trades

- Thermal Transfer
- Load Transfer
- Chemical Compatibility

→
- Component Modeling, Design, & Fabrication
- Component Test & Validation

→
- Develop FGM Design
- Model & Test/Validate a Full-Bore Short Section

Final Design Downselect

→
- Prepare Facilities
- Fabricate AGS Prototype Barrel

→
- AGS Composite Barrel Demonstration

NAVSEA DAHLGREN SURFACE WARFARE CENTER DIVISION

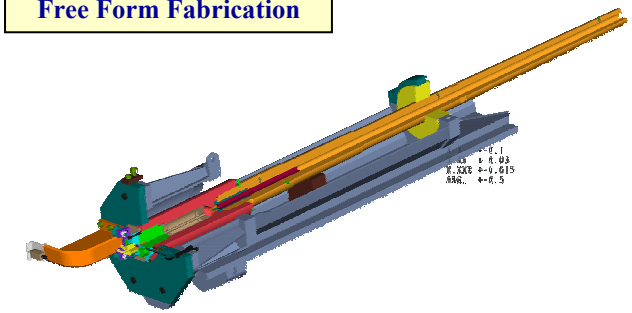
Development Approach

Refractory Barrel Technology

Technology Assessment

- Electroless Nickel-Boron
- Ta Sputtering
- Explosive Cladding
- CED
- EPVD
- Free Form Fabrication

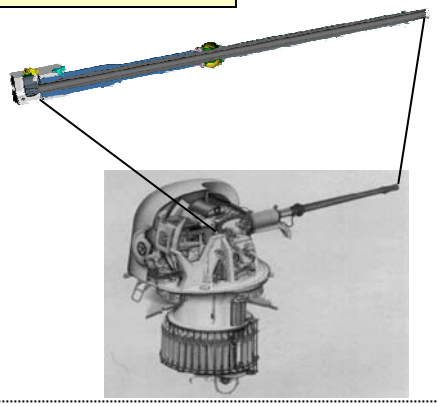
Screening Evaluations



Subscale Competition/Demo

- Explosive Clad Barrel Test
- EPVD Barrel Test
- Chrome Plated Barrel Test

76mm Gun Tests



Vendor Down select

Develop 155mm Refractory Barrel Design

Fabricate 155mm Refractory Barrel

Proof Test 155mm Refractory Barrel

Demo Test 155mm Refractory Barrel

Advanced Gun Barrel Technology

Transition Criteria

1 - Compliance with AGS Interface Control Document (ICD)

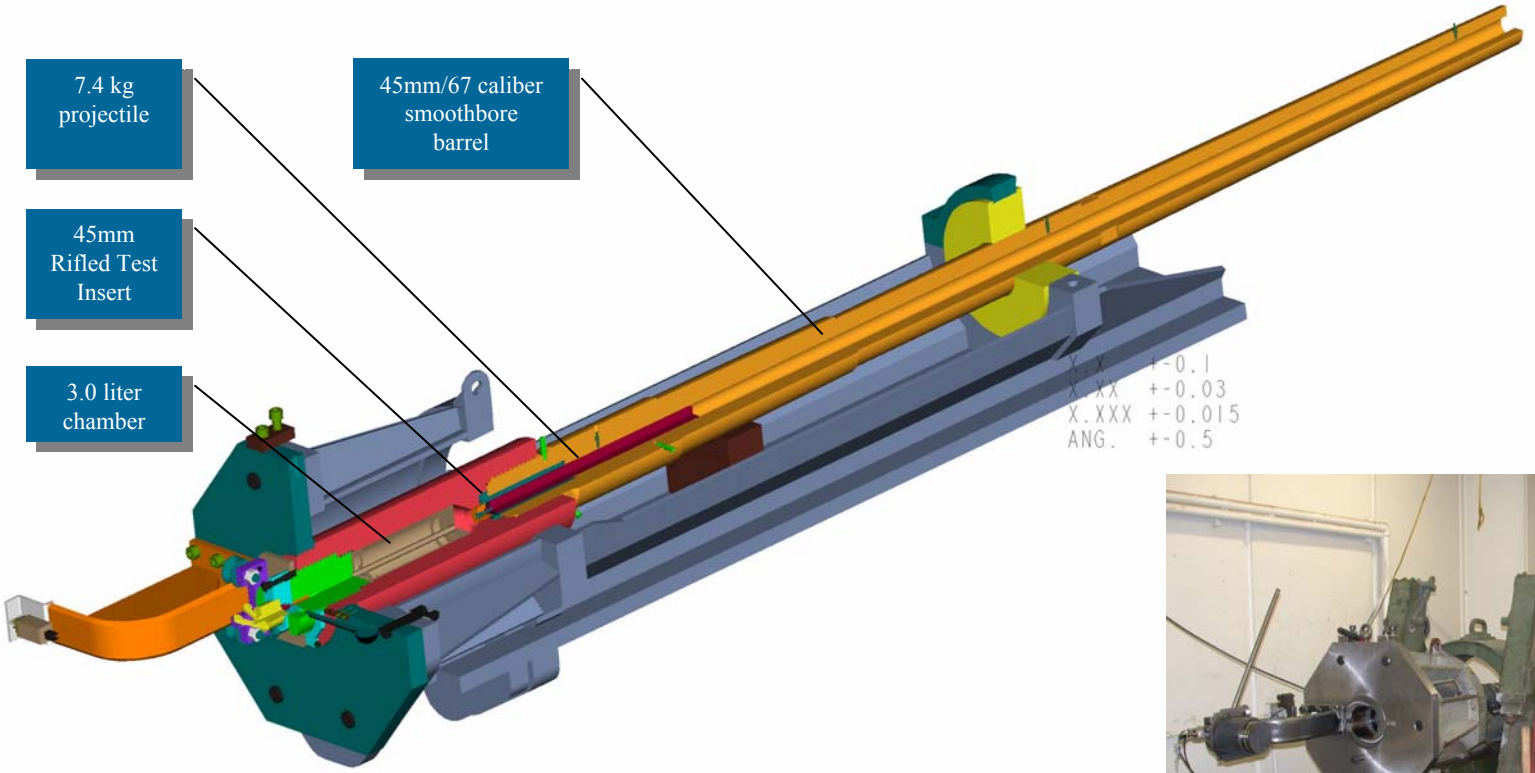
2 - Equivalent Ballistic Performance to Baseline AGS Barrel

3 - 50% Improvement in Barrel Life Over Baseline AGS Barrel

4 - Reduced Life Cycle Cost Compared to Baseline AGS Barrel

5 - Production and Gun Fire Testing of Full-scale Prototype

45mm Test Fixture



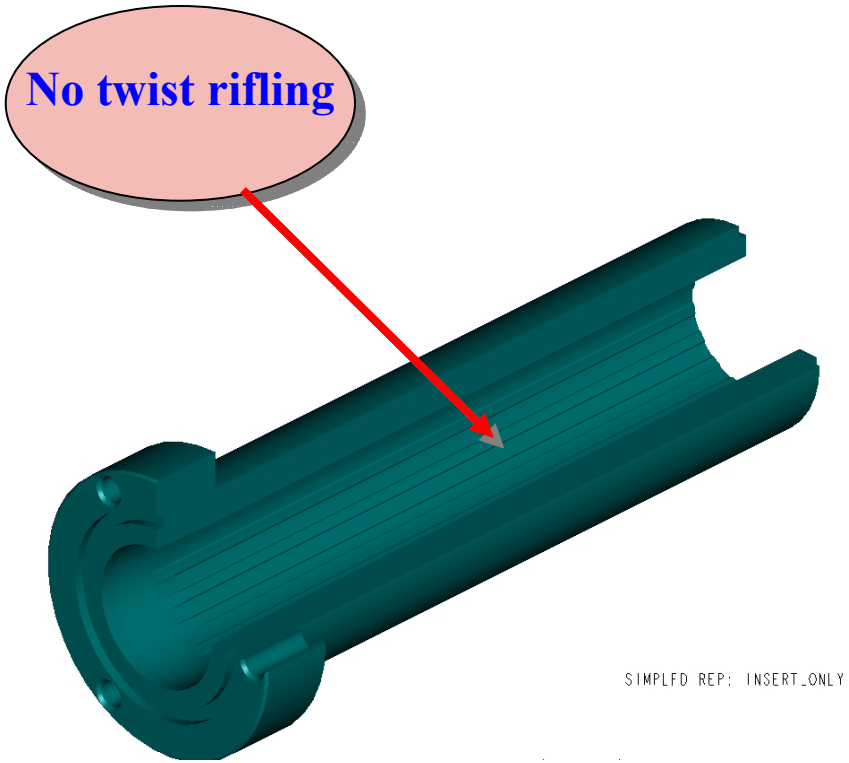
- Accurately reproduces the thermal, chemical and mechanical environment of a large caliber gun
- 50 shot test sequences used to evaluate coating adhesion and integrity
- Over 700 shots fired to date

45mm gun in place at UDLP test range

Provides cost effective means of evaluating coatings for large caliber gun application

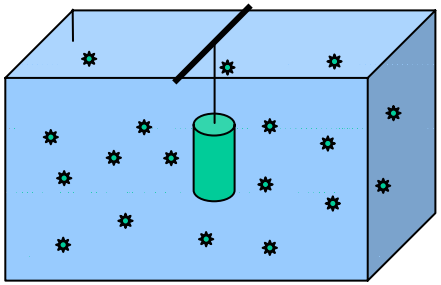
Test Insert

- Test insert used to evaluate the performance of advanced coating materials
- Insert includes shot start region and first few calibers of projectile travel
- Thickness sized to provide a strain level similar to the AGS barrel at maximum service pressure conditions for LRLAP
- Insert does not simulate compressive residual stress from autofrettage in the AGS barrel



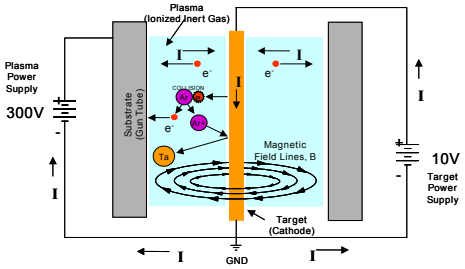
Candidate Coating Technologies

Electroless Nickel-Boron



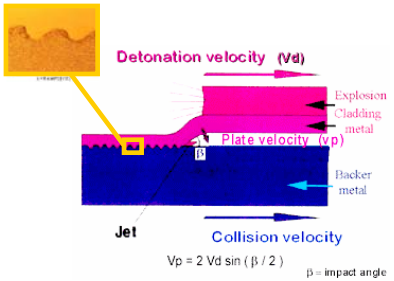
Catalytic plating process produces extremely uniform coating even on complex geometries

Sputtering



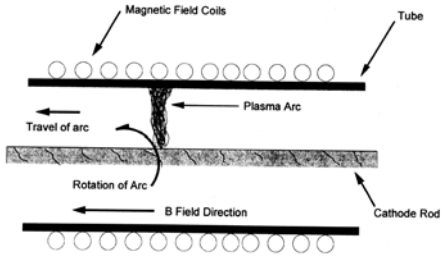
Material is sputtered, from a coaxial target, uniformly over the inside diameter of the barrel

Explosive Cladding



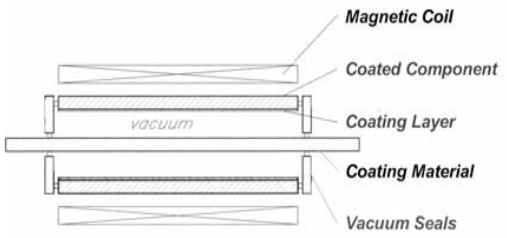
Tube of cladding material is mechanically bonded with the gun barrel in a collision driven by an explosive detonation

Coaxial Energetic Deposition



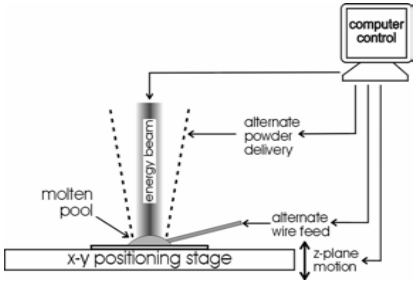
Plasma arc rotates around center conductor and travels along its length depositing material

Electromagnetically Enhanced Physical Vapor Deposition



Electrically controlled magnetic fields enhance the plasma environment of the physical vapor

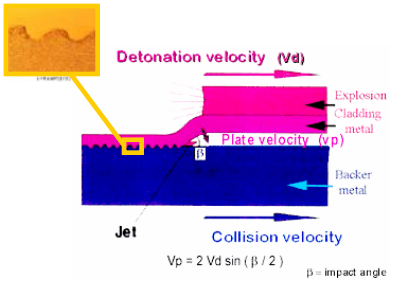
Solid Free-Form Fabrication



Engineered material is created by alloying of powdered and/or wire-fed metals

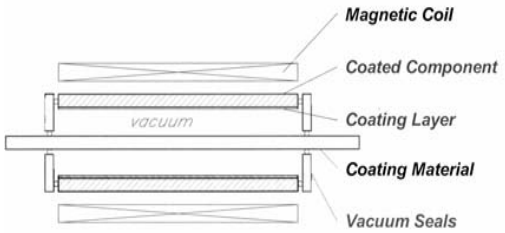
Candidate Coating Technologies

Explosive Cladding



Tube of cladding material is mechanically bonded with the gun barrel in a collision driven by an explosive detonation

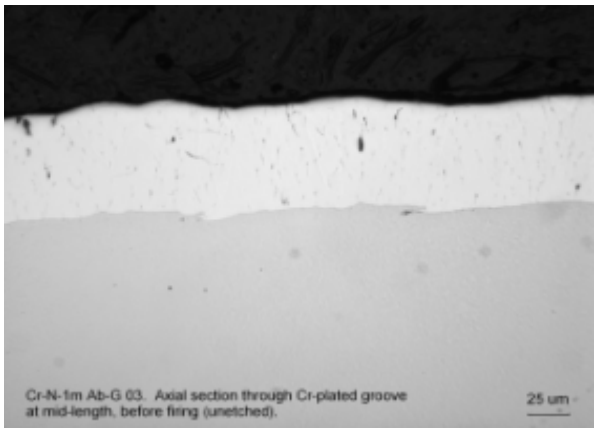
Electromagnetically Enhanced Physical Vapor Deposition



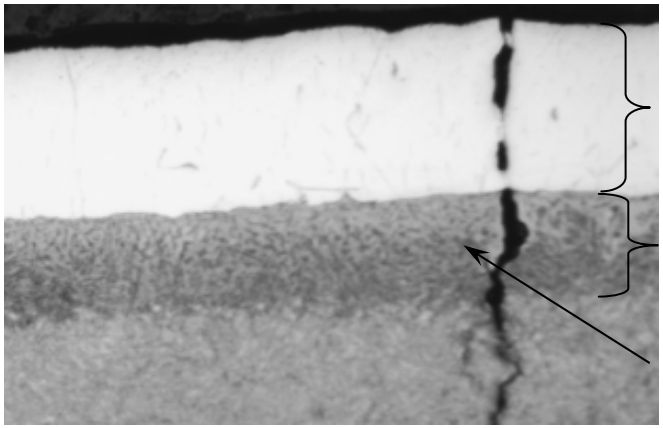
Electrically controlled magnetic fields enhance the plasma environment of the physical vapor

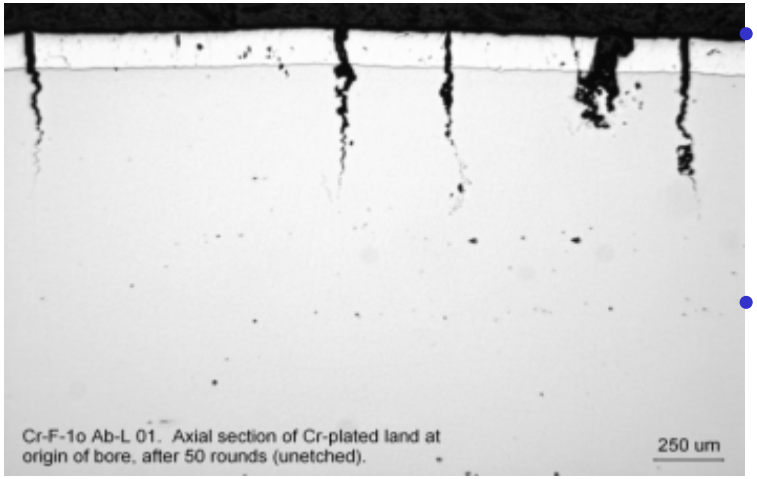
Chrome Plated Baseline

Unfired Sample



57 Firings

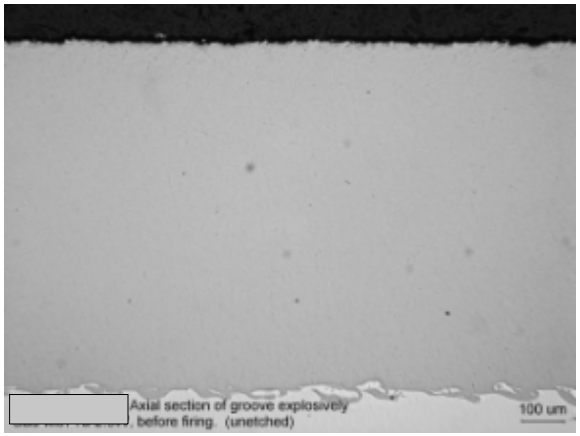




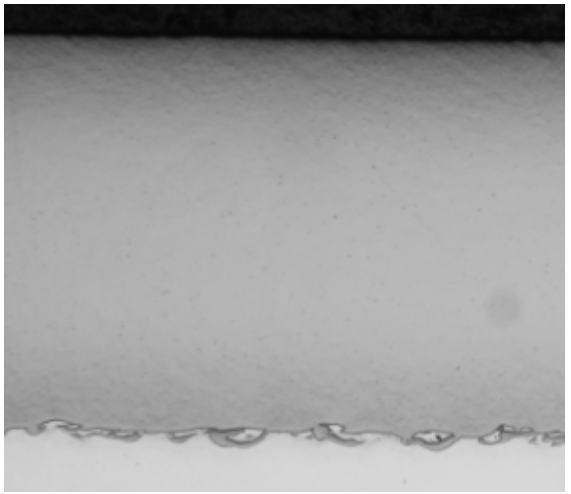
- Chrome plating showed very little evidence of wear, visual appearance compared favorably with 155mm gun barrel assets with approximately fifty shots
- Chrome plated baseline showed damage from heat checking, chemical attack and thermally altered grain structure similar to that characteristic of large caliber gun systems

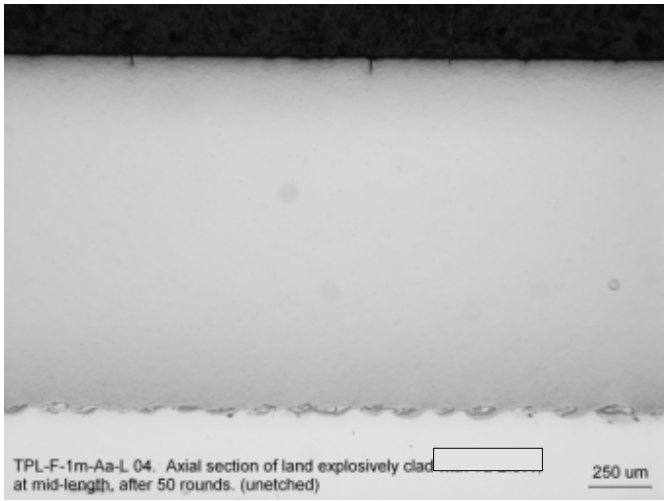
Explosive Cladding

Unfired Sample



50 Firings





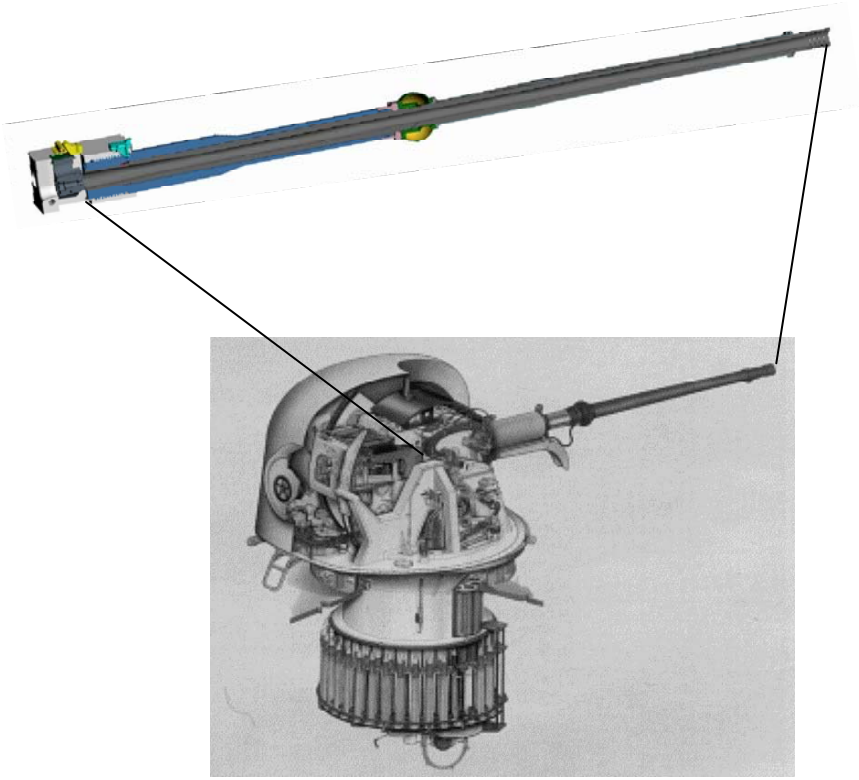
- Refractory metal alloy coating showed minimal effects after 50 firings
- Heat checks were significantly fewer and smaller than the chrome baseline
- The substrate appeared unchanged after 50 firings with no heat affected zone
- Interface between coating and substrate shows evidence of an overly energetic clad

Explosive Cladding

Prototype Barrel Assembly For Mk 75 76mm Gun

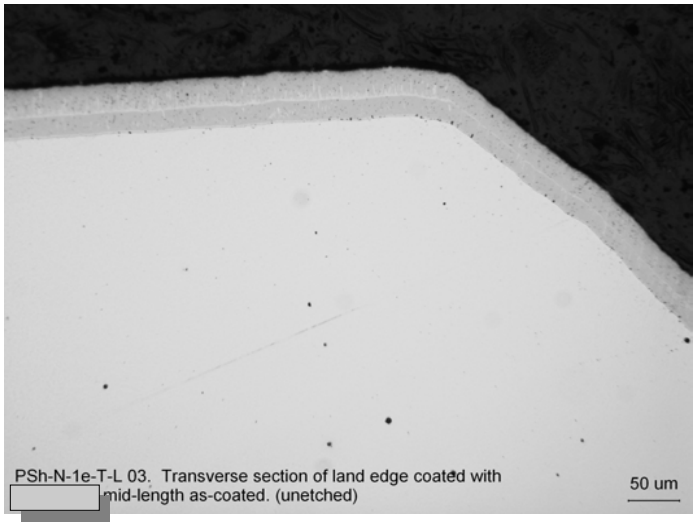
Key areas of development

- Cladding the complex geometry of the chamber
- Transitions and overlaps in successively clad layers
- Quantification of residual stresses resulting from the explosive event
- Machining operations in the clad alloy
  - Boring
  - Honing
  - Cutting
  - Grinding

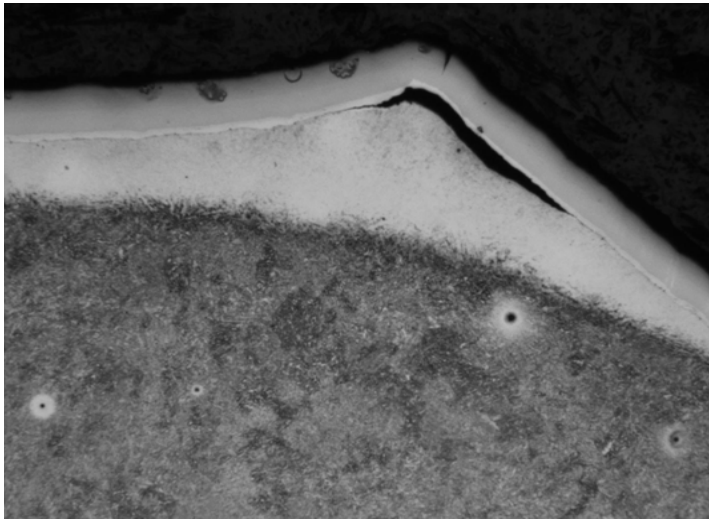


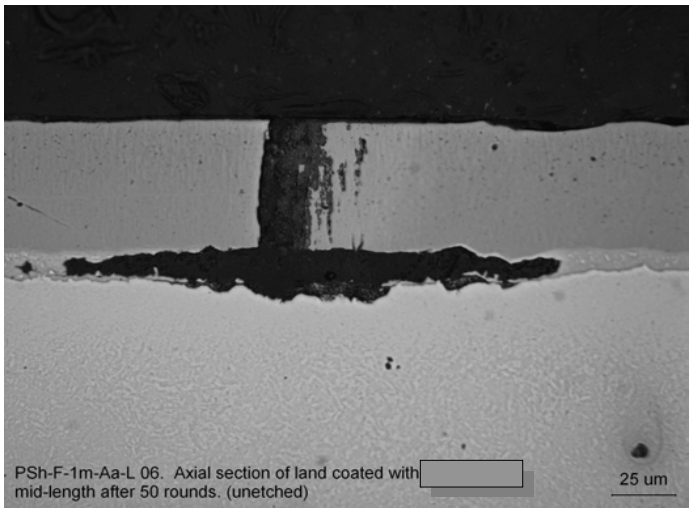
Electromagnetically Enhanced Physical Vapor Deposition

Unfired Sample



50 Firings





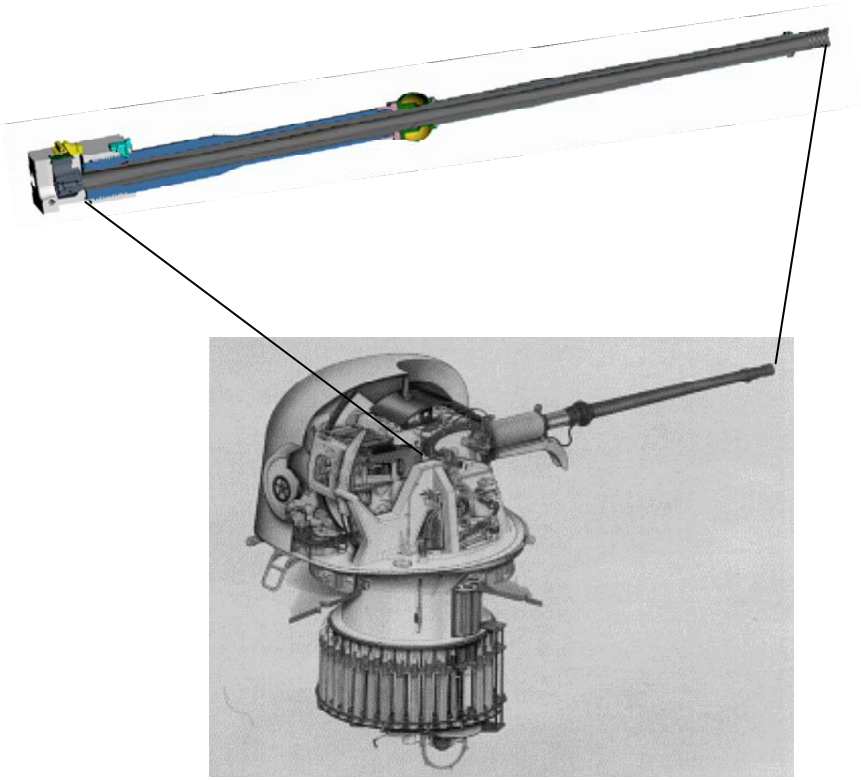
- Coating applied over thin interlayer showed good adhesion
- Less than 10% of material removed after 50 firings
- Interlayer corroded much more rapidly than either refractory metal or steel
- Interlayer separated from steel at point of highest heat input

EPVD

Prototype Barrel Assembly For Mk 75 76mm Gun

Key areas of development

- Application of an adherent coating that does not use an interlayer
- Application of a uniform coating on a barrel with complex ID and OD geometry

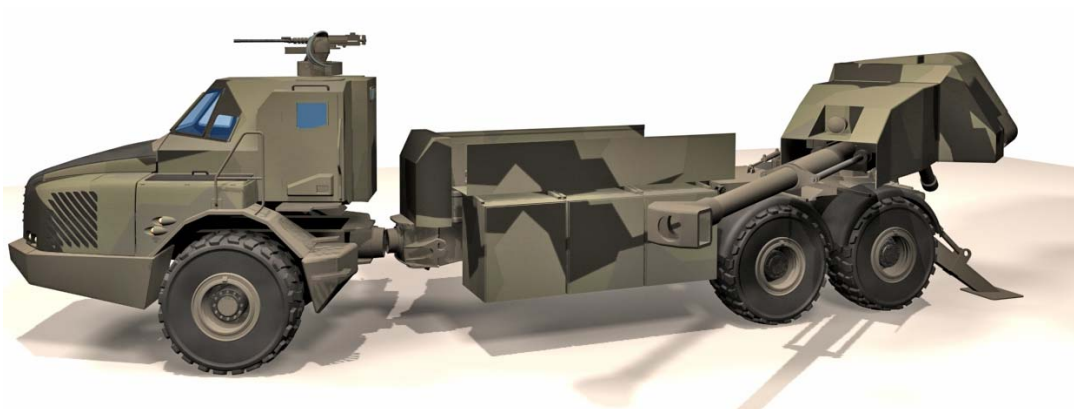


Program Status

- Completed screening candidate technologies based on performance in gun firing tests
- Selected two for continued development and demonstration in 76mm scale, Explosive Cladding and Electromagnetically Enhanced Physical Vapor Deposition (EPVD)
- Completed producibility reviews on both technologies incorporating information into preliminary designs for 76mm prototype barrels and identifying key areas of development
- Currently working to demonstrate successful resolution of all key issues for both technologies

Path Forward

- Prototype 76mm barrel assemblies scheduled to be complete end of ‘05 with rapid fire testing conducted early ’06
- Down-select to single technology for application in full scale 155mm barrel to be built in ’06 – ’07
- Demonstration of technology via proof fire testing and rapid fire testing in 155mm in ‘07



Archer Artillery Program
Mr. Ulf Einefors

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BOFORS DEFENCE

155 mm FH 77 L/39

- *In service with the Swedish, Nigerian and Indian armies*
- *More than 700 howitzers produced.*

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BOFORS DEFENCE

Volvo Articulated Hauler

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BOFORS DEFENCE

FH 77 Upgrade to self-propelled FH77A

Swedish army improvement program 1993-1998

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BOFORS DEFENCE

STAFF REQUIREMENT

- *155 FH 77 BW L52 System is intended for;*
  - *Swedish defence operations (brigade/division fire support)*
  - *International peace-keeping/enforcement operations.*
- *Capabilities*
  - *High strategic, operational and tactical mobility*
  - *Extremely good crew protection especially for peace-keeping/enforcement operations*
  - *Precision strike firepower*
  - *Massive sustained firepower for support/deep firing operations (> 25 tons of ammunition per gun and 24h)*
  - *Low LCC*

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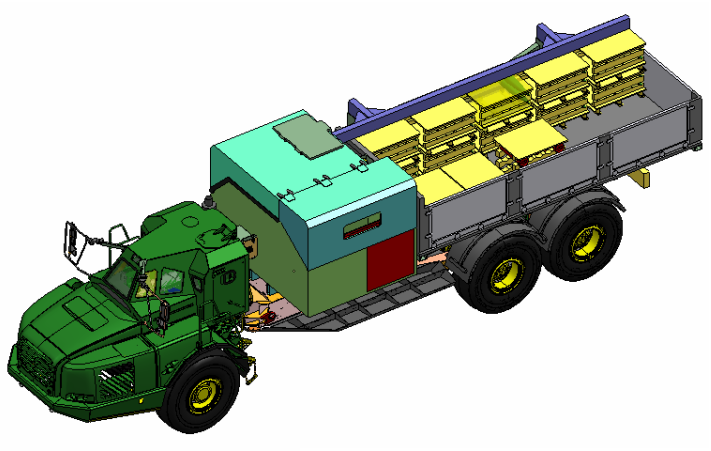
BOFORS DEFENCE

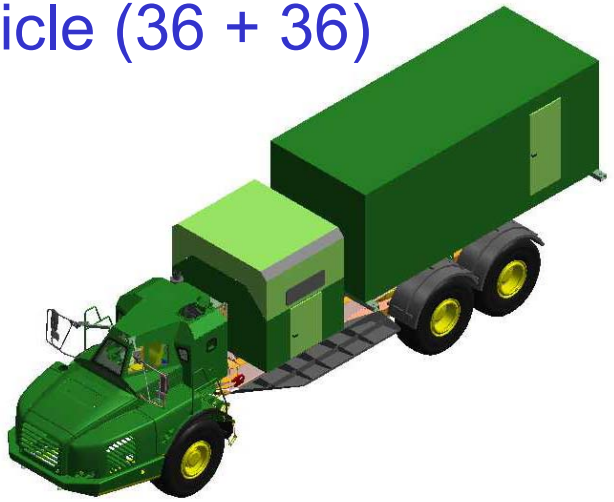
Artillery program
Sweden/Denmark

ARCHER L52 (36 + 36)



• Ammunition Vehicle (36 + 36)

Uniflex2 modular charges



• Support Vehicle (8 + 8)

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BOFORS DEFENCE

AMMUNITION

UNIFLEX2 Modular charge system (insensitive)

- New type of propellant (Fox/IM)
- Top charge 6.5 modules (25 l chamber)
- Can be fired down to 1 modules
- Half modules for more MV steps (12)

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BOFORS DEFENCE

AMMUNITION

EER40 Improved

- Improved long range shell tested during trials in India (>40 km)
- HEER40 Improved IM will fulfill IM specification (STANAG 4439)
- Pre qualification is ongoing

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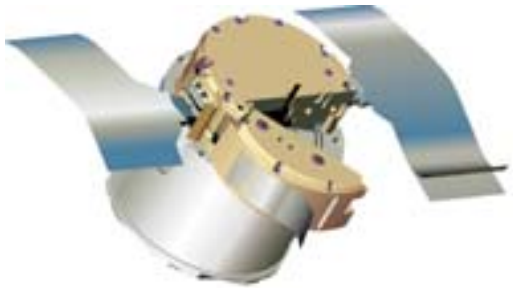
BOFORS DEFENCE

AMMUNITION

EXCALIBUR

155 BONUS II SFM



Ammunition family FH77

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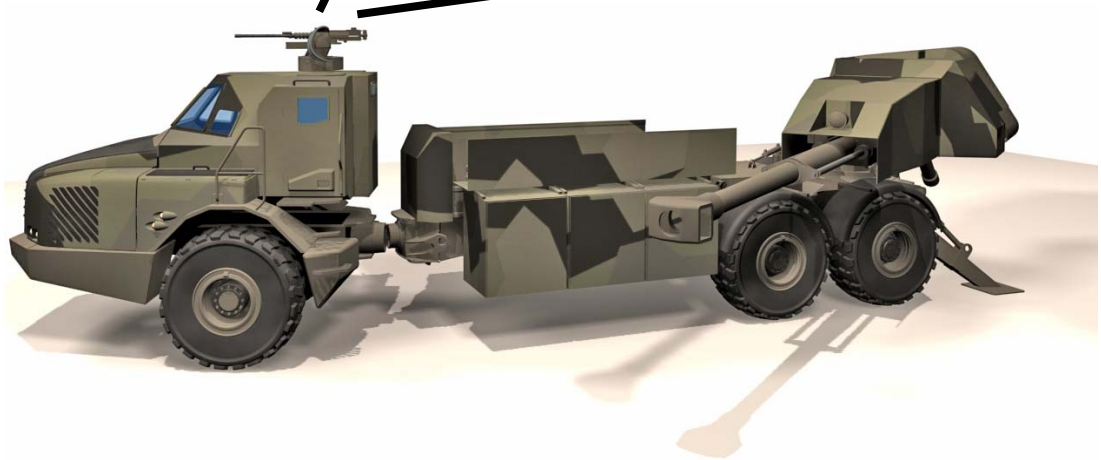
BOFORS DEFENCE

LEMUR Remote Weapon System

- *Automatic mask measuring*
- *Direct sight*
- *Surveillance*
- *Secondary armament*
- *Smoke launchers*



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BOFORS DEFENCE

Performance

Weight	30 tons
Width	3.0 m
Length	14.1 m
Height	3.3 - 3.9 m
Air transportable	A 400M
Maximum speed	70 km/h
Engine power	340 hp
Ammunition storage	Projectiles 20+20 Charges 20+20
Deployment time	< 30 s
Redeployment time	< 30 s
Elevation and Traverse	0 to +70 and -75 to -75 degrees
Firing range	> 40 km (HE-BB)
Rate of fire	3 rounds 15 s, 9 rounds/min
MRSI	6 rounds
Protection level	7.62 AP, Mines 6 kg (Level 2 STANAG 4569)

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BOFORS DEFENCE

Demo System Manufacturing

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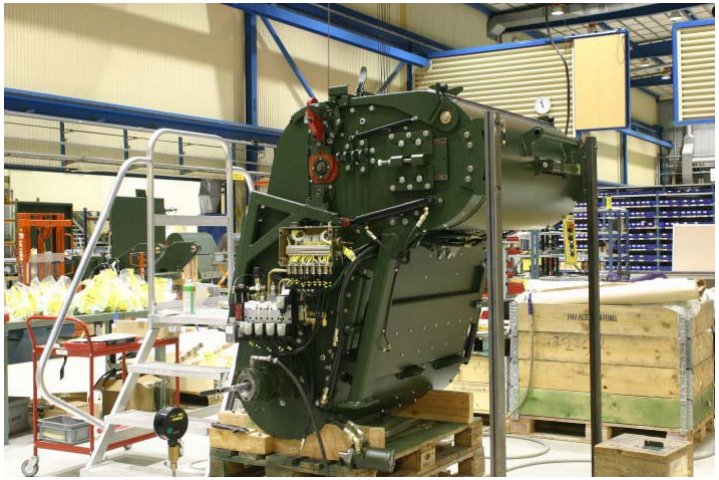
BOFORS DEFENCE

Sub System Assembly



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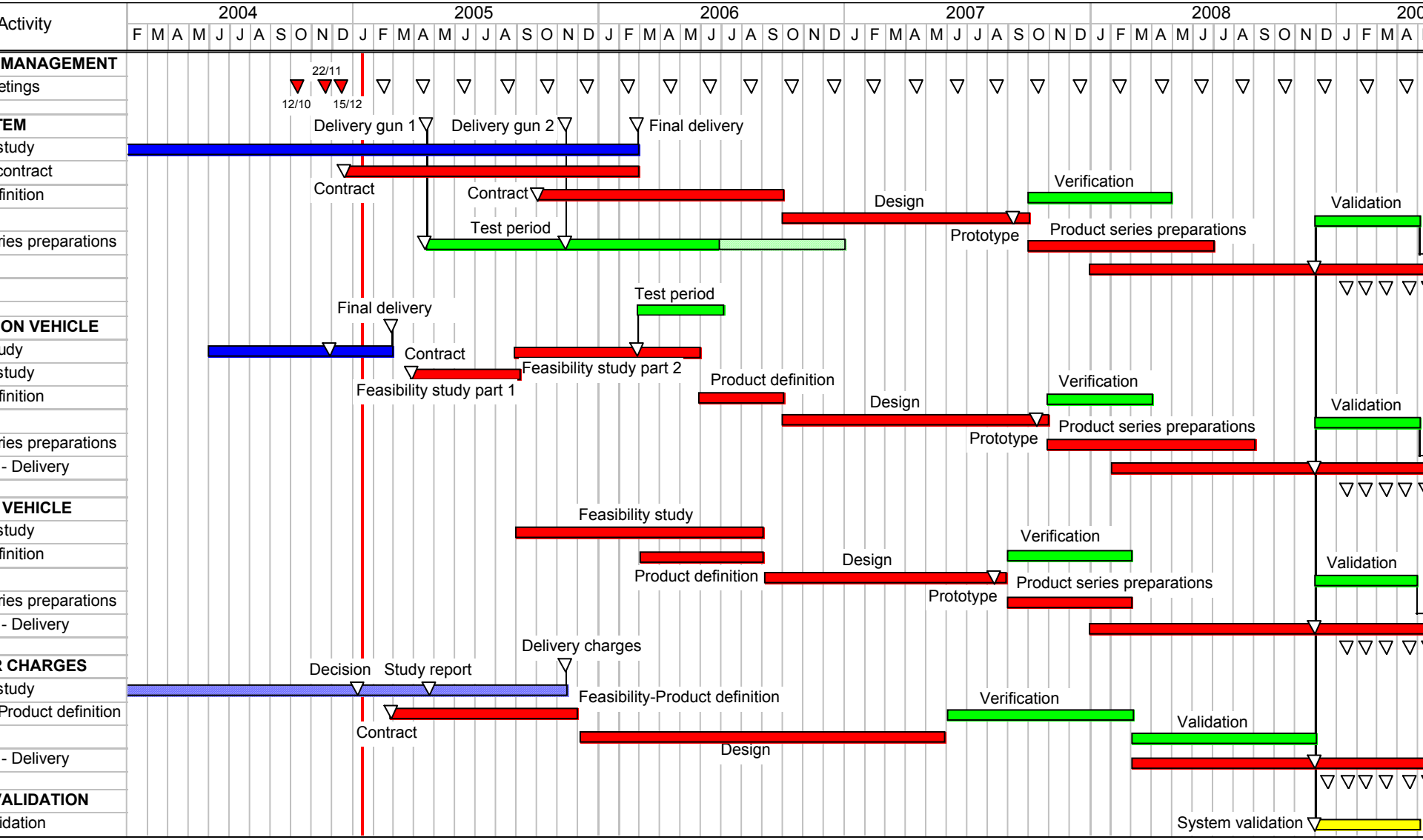
BOFORS DEFENCE

Program Time Schedule



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BOFORS DEFENCE

Key factors ARCHER L52

- *Autonomous operations procedures*
- *Long-Range Precision Engagement System*
- *Engagement of visible targets by direct fire capability*
- *Self-protection through integrated RWS (LEMUR)*
- *High momentary effect in target through MRSI (12 M.V. step charge system)*
- *Greater range (40 km)*
- *Strategic and tactical mobility*
- *Endurance*
- *Commercial chassis (Volvo)*
- *Cost-effective*

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BOFORS DEFENCE

UESTIONS ?

BOFORS

M865 TID Improvement Study

Presented by: Jason Gaines, M865 Systems Engineer, GD-OTS

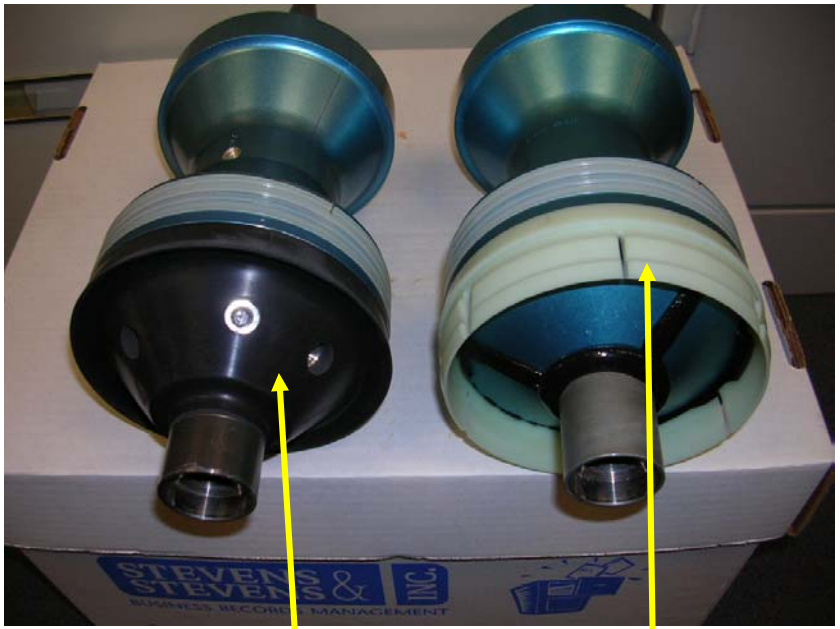
Introduction to the 120mm M865

- The M865 Kinetic Energy (KE) training round, in service with the United States Army's main battle tank fleet, provides a realistic training device displaying the accuracy and time-of-flight of the M829 series service rounds.

- The fin stabilizer provides a safety feature limiting the overall flight range to under 8 km.

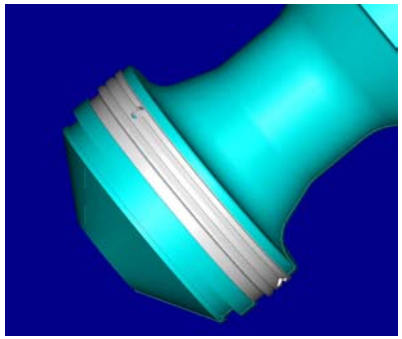
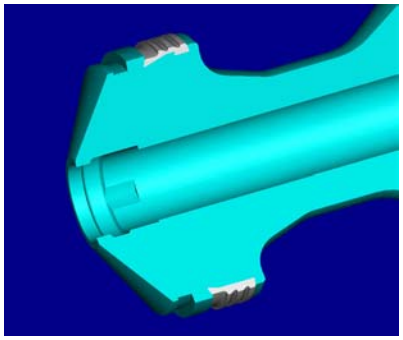
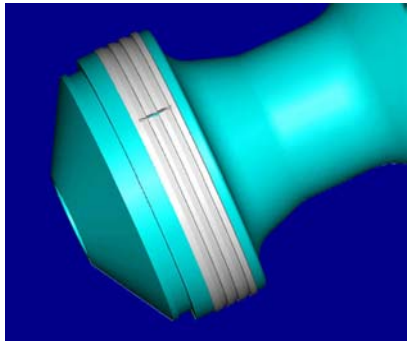
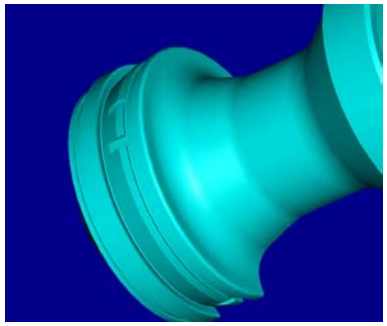
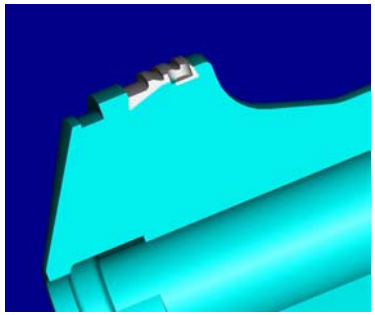
TID Background

- Target Impact Dispersion (TID) of the M865 at cold temperature (-32°C) has seen a consistent increase since the inception of the new design in FY99.
- This increase is largely due to the large number of fliers at cold temperature.
- The new design utilizes a plastic snap on insert cover which connects the projectile to the cartridge case adapter. The previous design utilized a rubber cuff which was bolted to the cartridge case adapter.

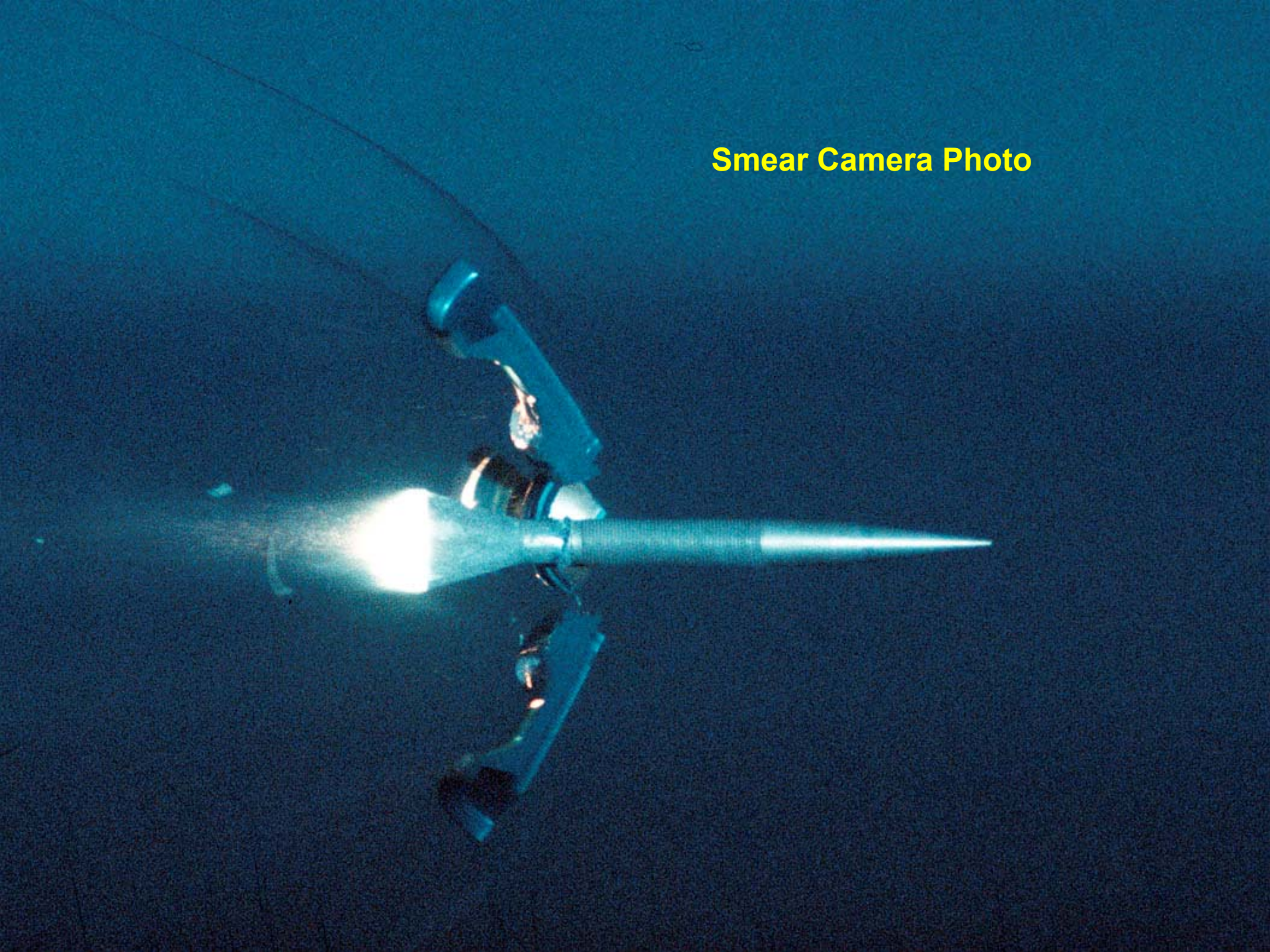


Project Objective

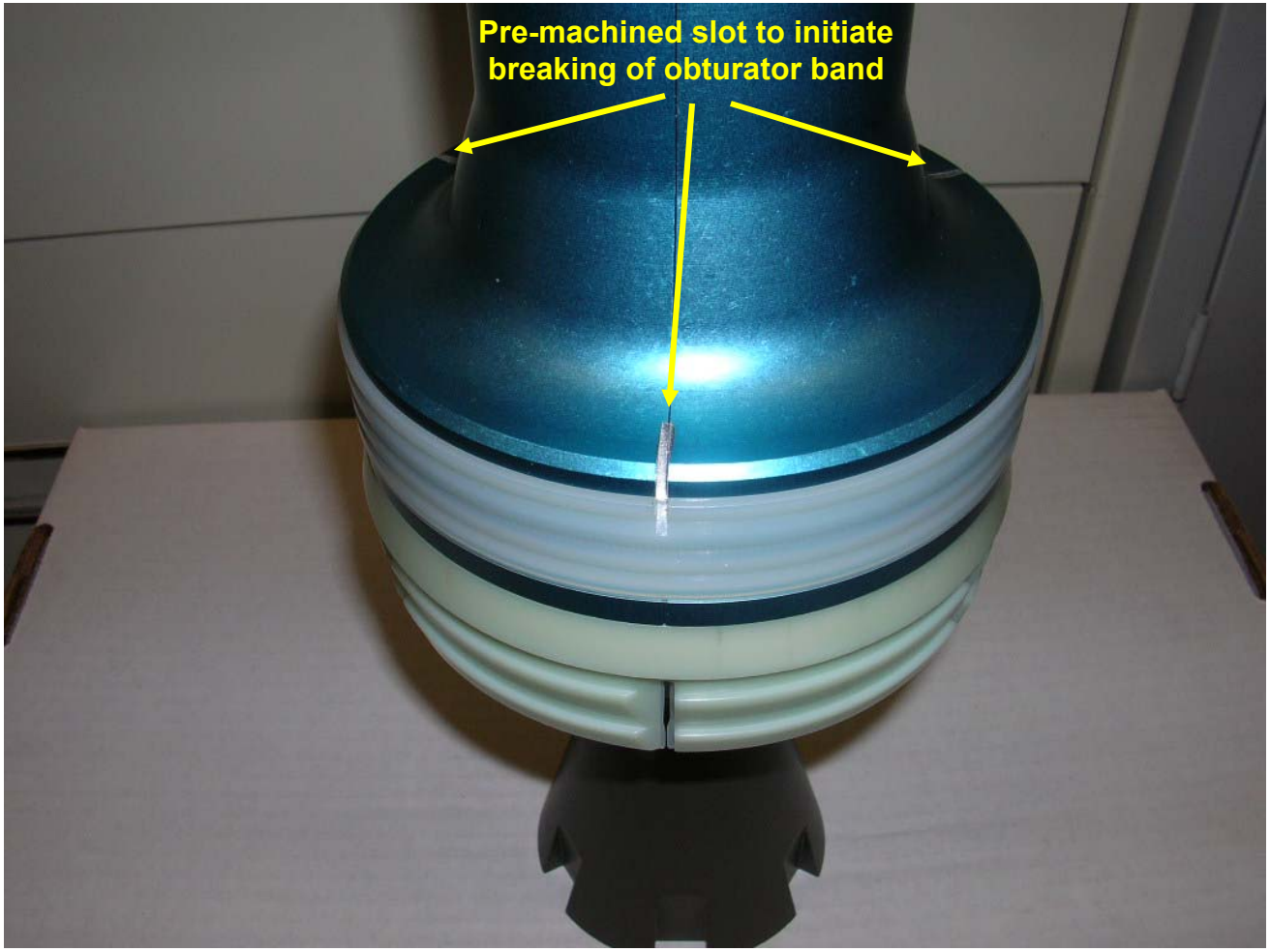
- To Improve the M865 KE Training Round's cold TID by reducing the number of "fliers" through redesigning the nylon obturator band and aluminum sabot.

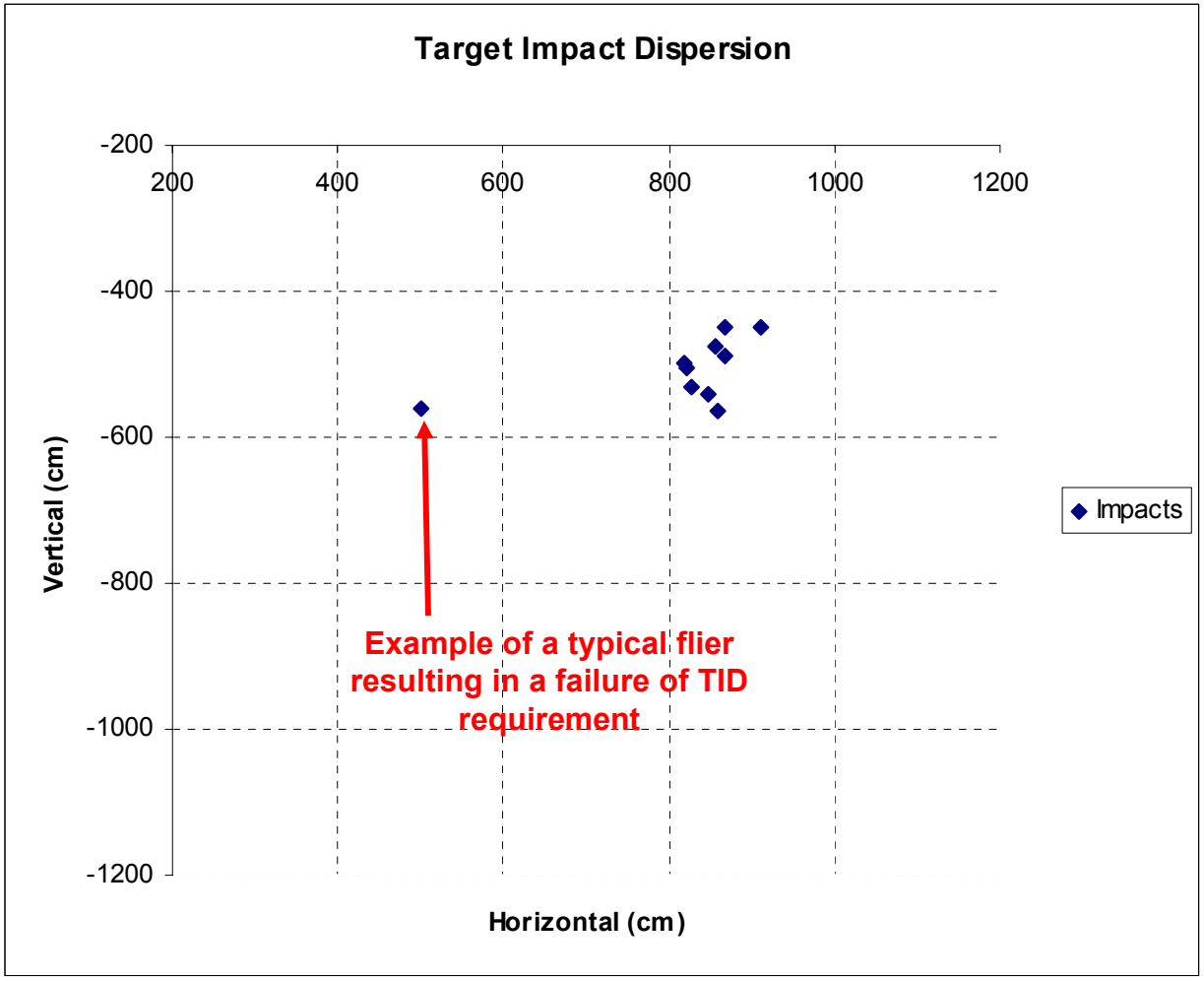
High Speed Flight Follower


Smear Camera Photo

Current M865 Projectile Design



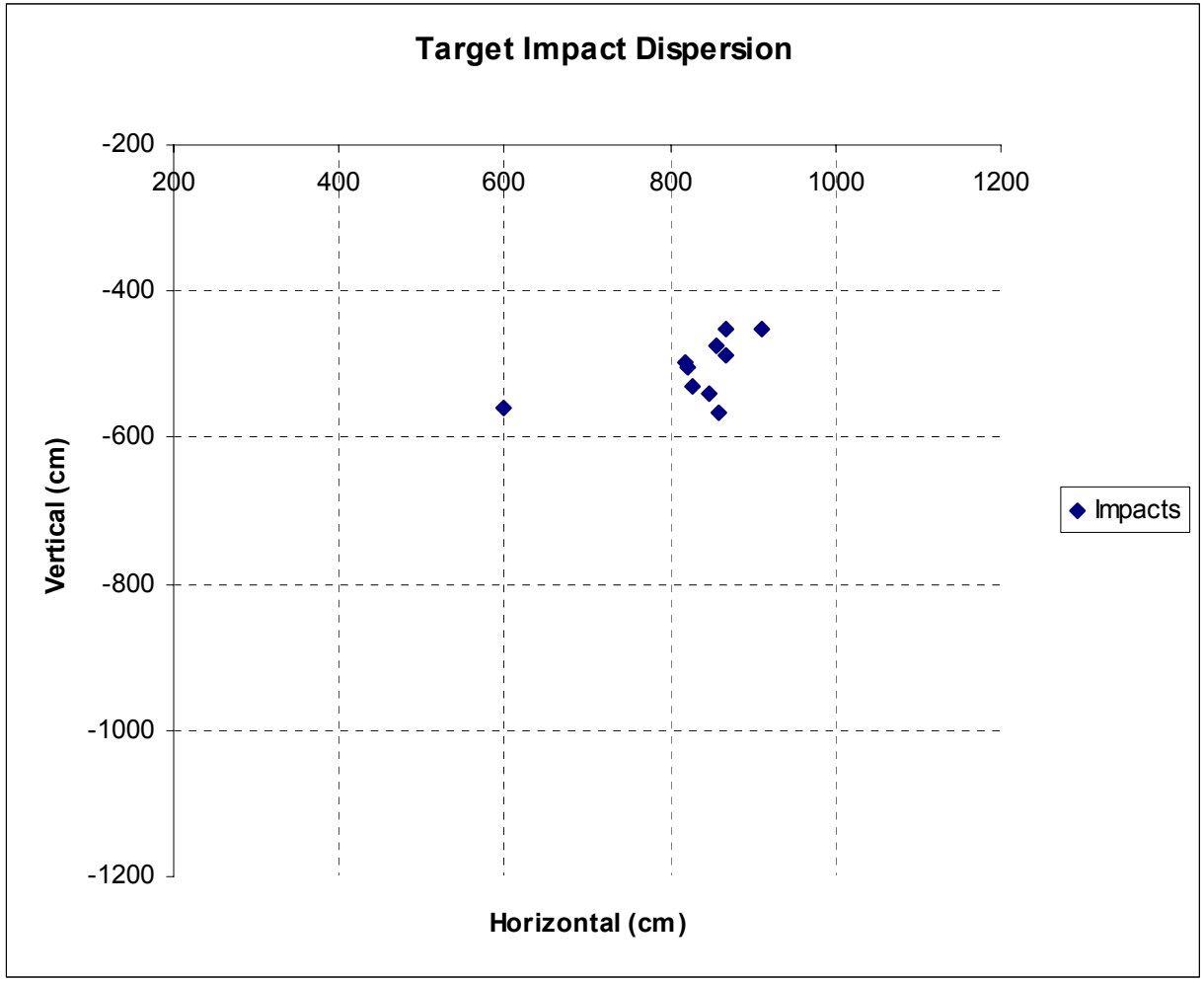
Impact Result at -32°C



TID (mils)		
	X	Y
First 5	**0.61**	**0.12**
Second 5	**0.12**	**0.13**
Pooled	**0.44**	**0.13**

The M865 Performance Specification requires a TID of .30 x .30 or lower to accept a cartridge lot.

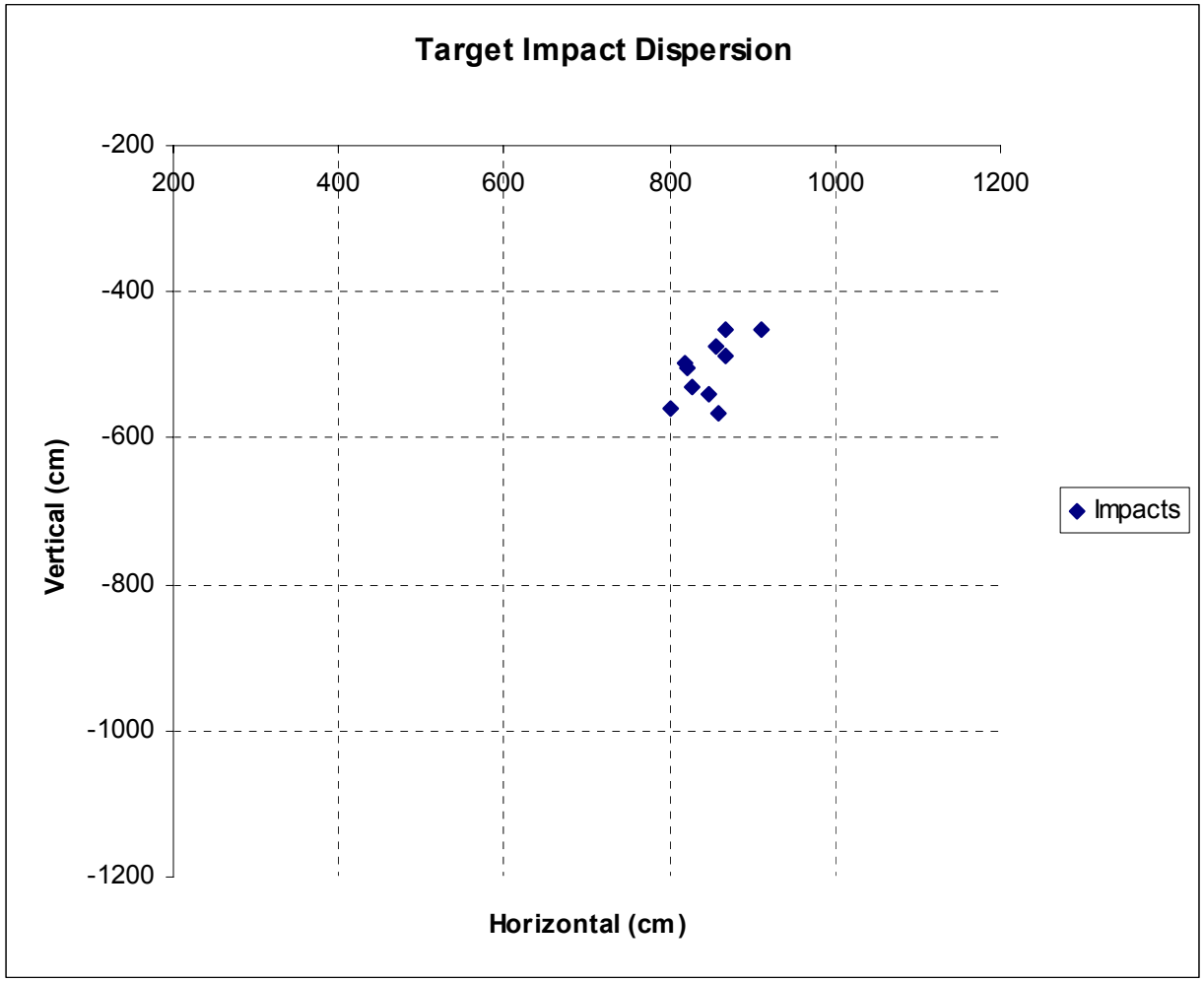
Improved Impact Result at -32 °C



TID (mils)		
	X	Y
First 5	0.43	0.12
Second 5	0.12	0.13
Pooled	0.32	0.13

The M865 Performance Specification requires a TID of .30 x .30 or lower to accept a cartridge lot.

Desired Impact Result at -32 °C



TID (mils)		
	X	Y
First 5	**0.10**	**0.12**
Second 5	**0.12**	**0.13**
Pooled	**0.11**	**0.13**

The M865 Performance Specification requires a TID of .30 x .30 or lower to accept a cartridge lot.

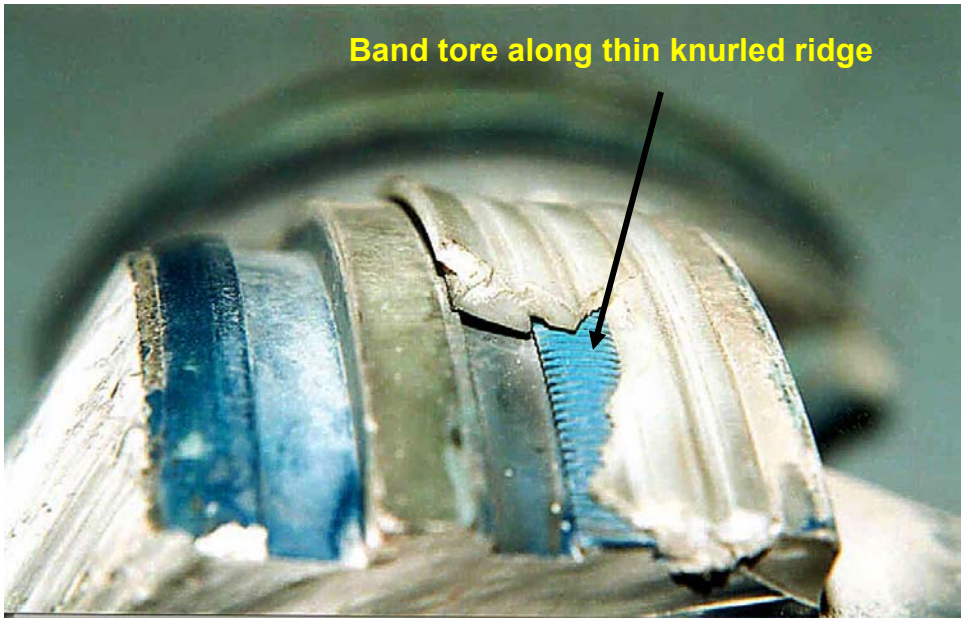
M865 Sabot Recovery History

- General Dynamics – OTS Red Lion Operations has been evaluating recovered sabot segments for the past 10 years.
- After the design change in 1999, the focus was primarily on the function of the nylon obturator band.
- Three major phenomena where discovered which raised concern that an asymmetrical discard of the sabot could be contributing to the sometimes, erratic flight of the M865 Projectile at cold temperatures.
    1. Circumferential tearing of obturator band
    2. Gas intrusion beneath aft end of obturator band
    3. In-bore obturator band rotation

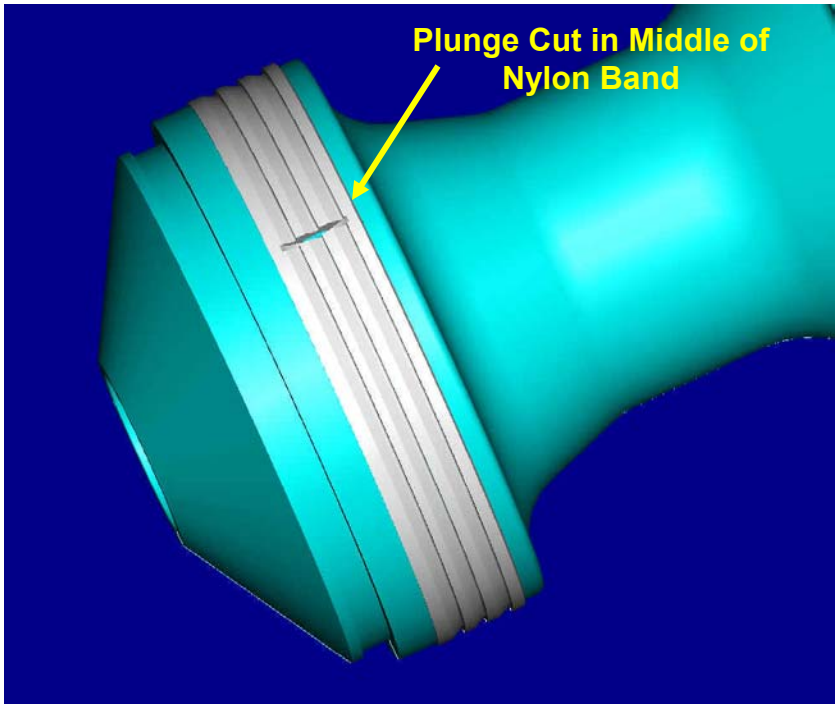
Circumferential Tearing

- Sabot recovery analysis revealed evidence that the nylon obturator band did not always break along the pre machined slot.

- In many instances, the fracture reaches the area of thinner nylon over the knurled area between the dovetails and the fracture will on occasion, especially at cold temperatures, propagate circumferentially rather than directly aft.

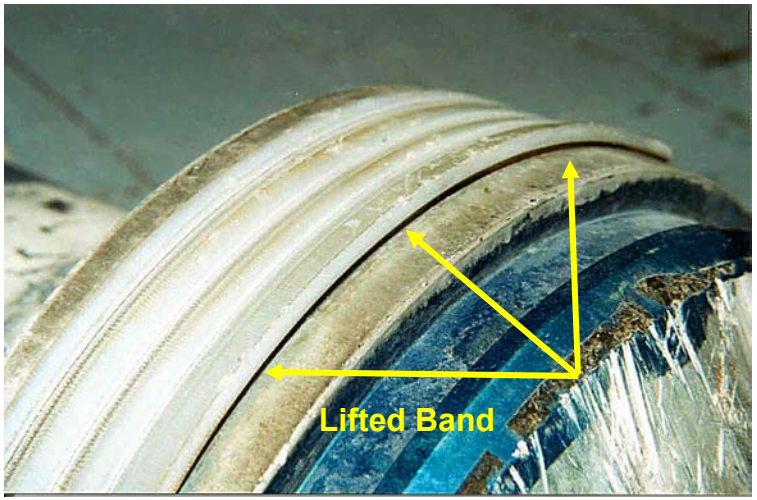


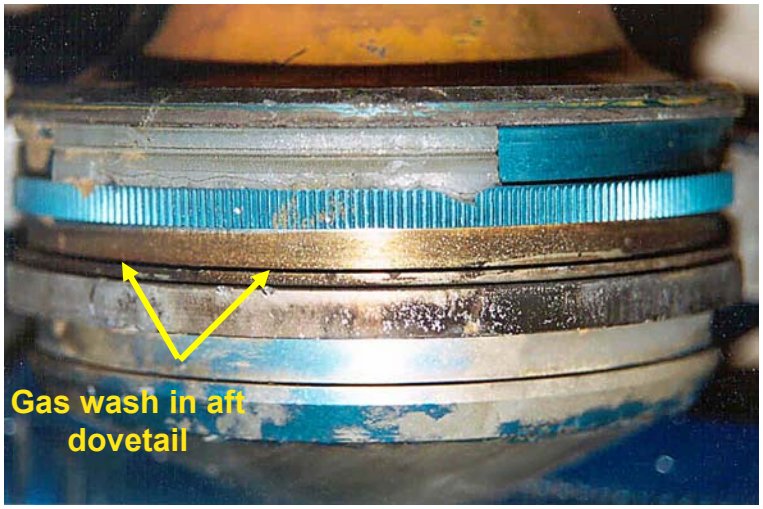
Design Feature One – Plunge Cut



- The plunge cut is designed to prevent circumferential tearing of the obturator band.
- The plunge cut is located directly in the center of the band so that each shoulder, forward and aft, of the cut have an identical thickness. This will promote an even, symmetrical break.

Gas Intrusion Beneath Nylon Band

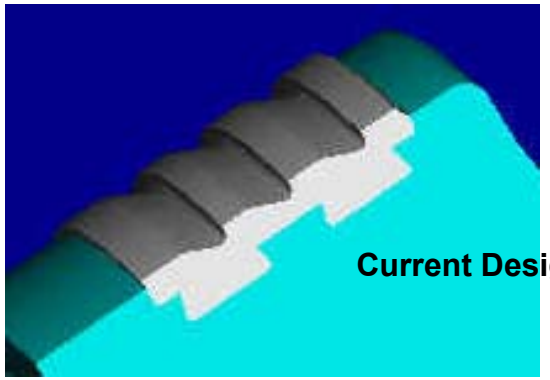


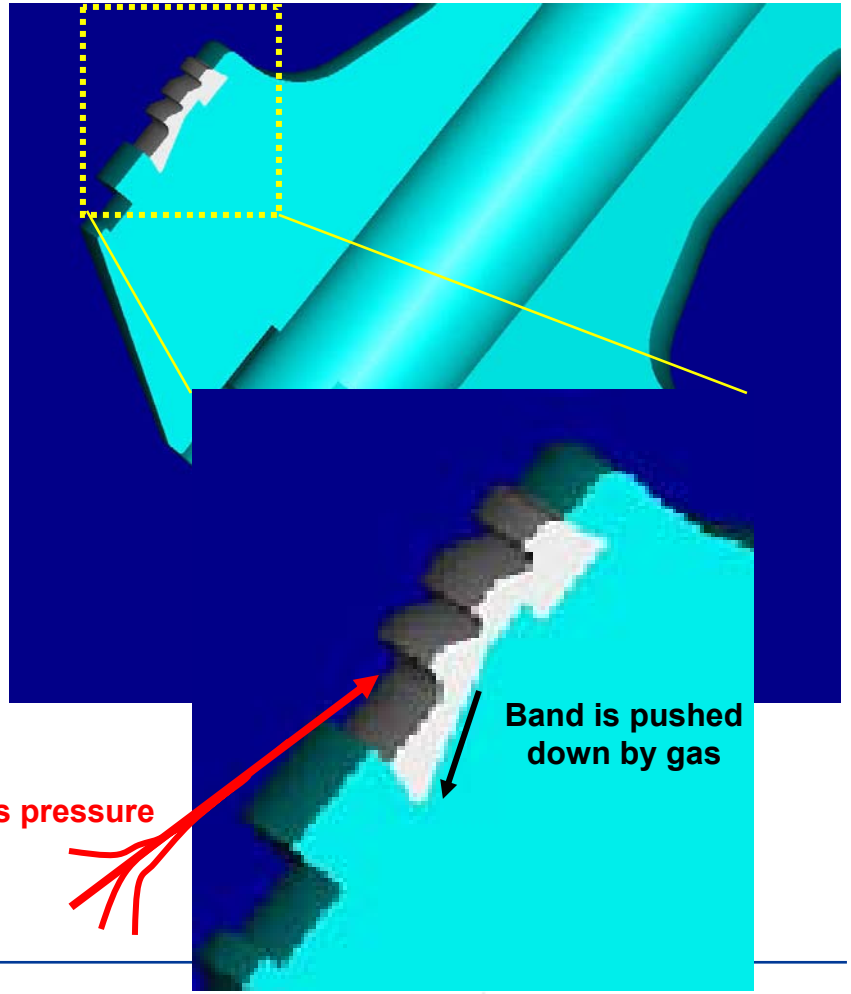


- It was noticed during the sabot recovery evaluation that there was evidence of gas intruding under the aft dovetail of the nylon band.
- The evidence of this lifting was shared with the technical community and the modified dovetail design was created and became known as the ARL design.

Design Feature Two – ARL Groove

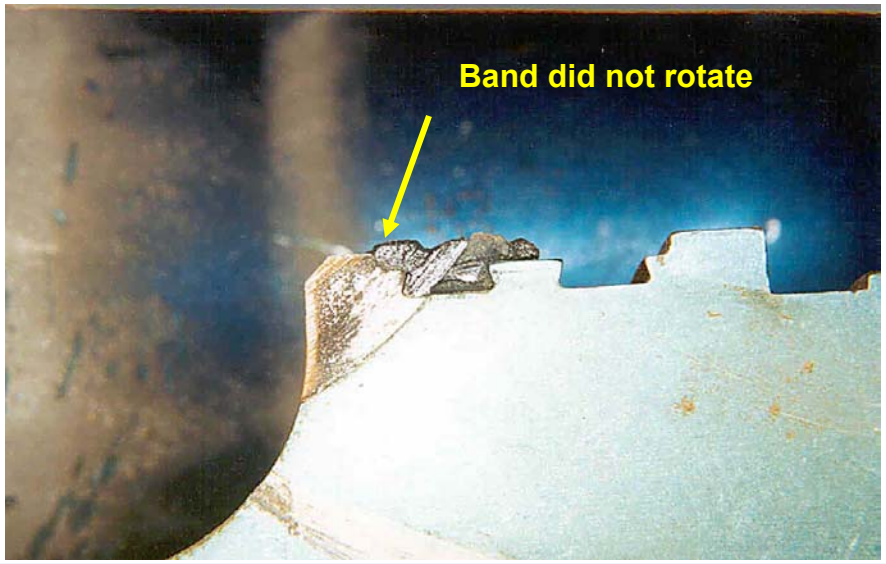
- Designed to prevent gas intrusion underneath the obturator band causing the band to lift prior to exiting the gun tube.
- In theory the gas should force the obturator band into the extended dovetail.

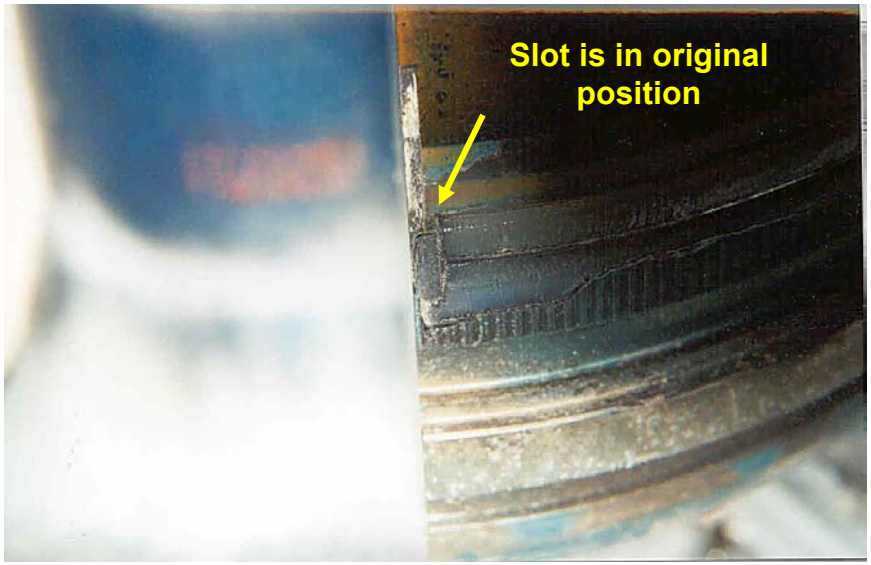




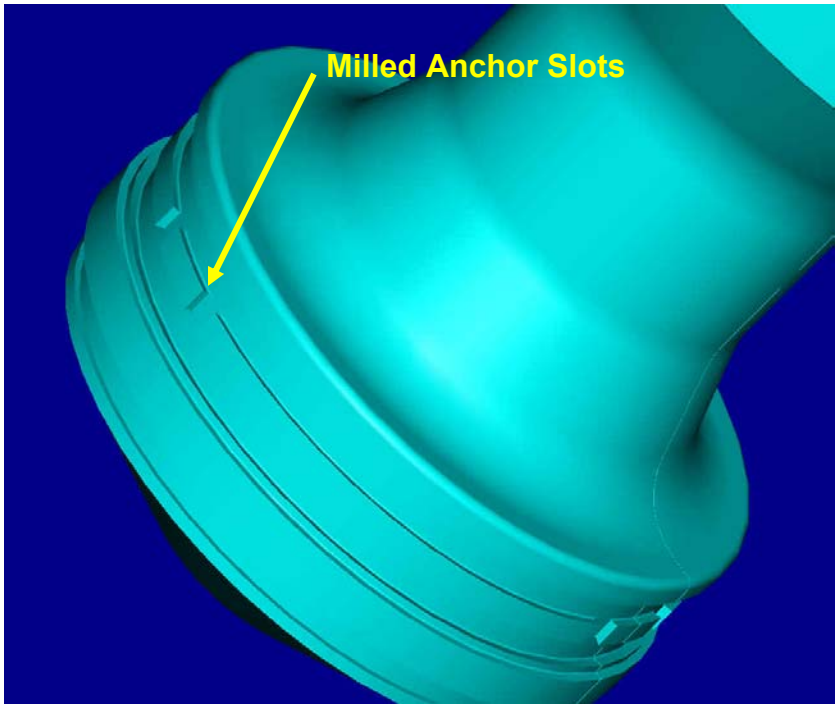
Band Rotation

- It was noticed that on some recovered sabots there was evidence of in-bore band rotation.
- Some recovered sabot segments showed evidence of the slot being intact and shifted circumferentially up to ten or twenty degrees.
- This rotation would not stop the discarding of the sabot, but it would certainly create a different discarding process than what is normally seen.





Design Feature Three – Anchor Slots



- Anchor slots are designed to prevent the obturator band from rotating while in bore.
- Rotation of the band in-bore causes the band to break in a location other than the precut slots resulting in a negative affect on final TID results.

Design Combinations

- 5 test groups were developed from the three design features

	ARL Groove	Plunge Cut	Anchor Slots	Ballistic Test Qty.
Design 1 (T_1)		X		30
Design 2 (T_2)	X	X*		30
Design 3 (T_3)			X	30
Design 4 (T_4)		X	X	30
Design 5 (T_5)	X		X	30
Control Rounds				60

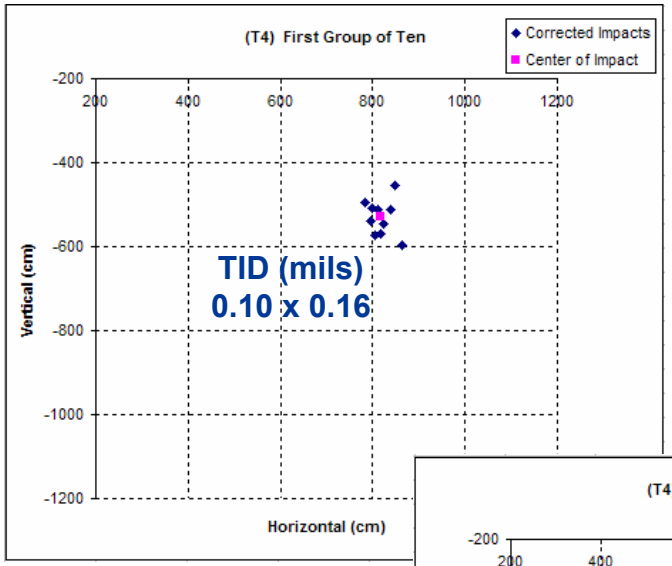
*** Plunge cut had to be modified from a slot to a drill cut due to modified obturator band**

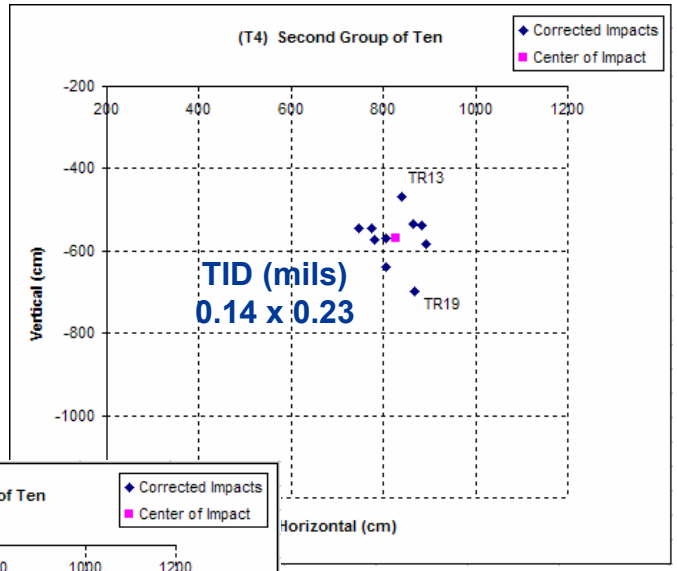
Summary of Results

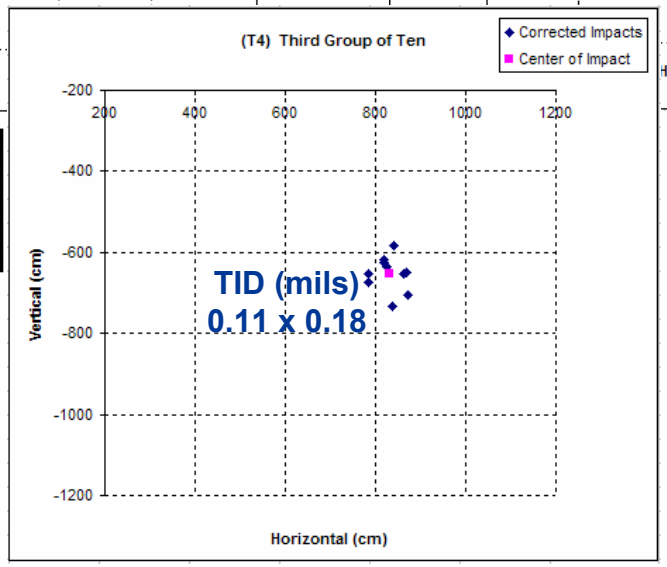
	No of Rounds Fired	Fliers[1]	Percent Fliers	Improvement over Control Rounds	Total Average TID
Design 1	30	7	23.3%	8.3%	.20 x .27
Design 2	30	6	20%	11.6%	.25 x .25
Design 3	30	6	20%	11.6%	.27 x .26
Design 4	**30**	**2**	**6.6%**	**25%**	**.12 x .19**
Design 5	30	4	13.3%	18.3%	.21 x .23
Controls	60	19	31.6%	-	.26 x .26

[1]Any single round which resulted in an impact greater than 100 cm from the center of impact was considered a flier during test evaluation.

Design 4 Resultant Impacts



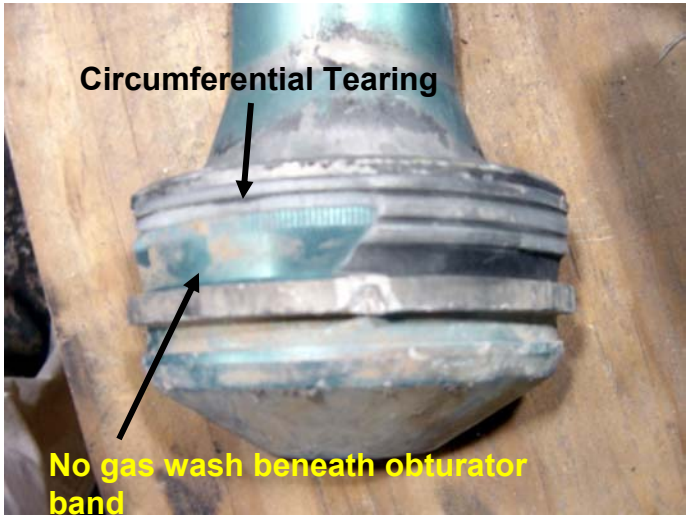




3 out of 40 test since the design change have had a TID result below a 0.20 x 0.20.

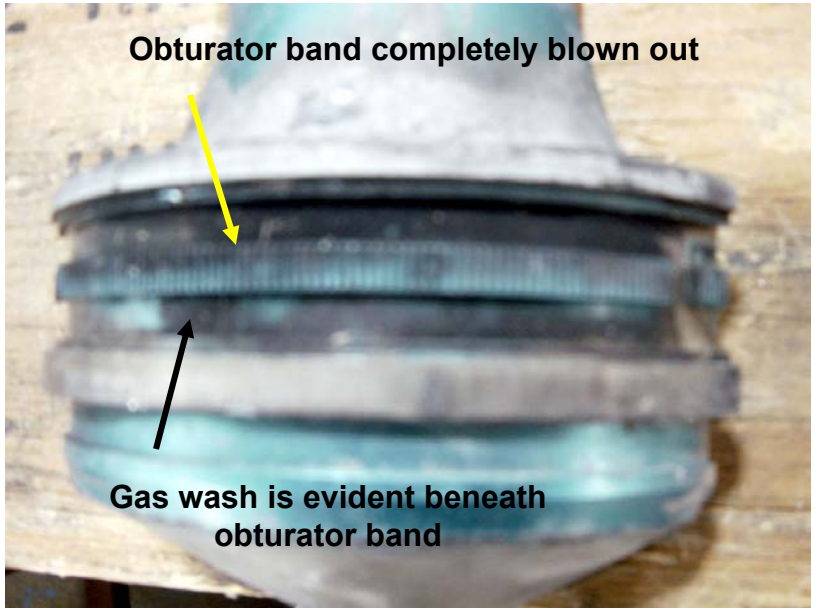
Recovered Sabots – General results

1. ARL Groove
   - Gas did not intrude underneath nylon obturator band.
   - There were many recovered sabots that exhibited circumferential tearing.
   - In most instances large portions of the obturator band remained in tact.



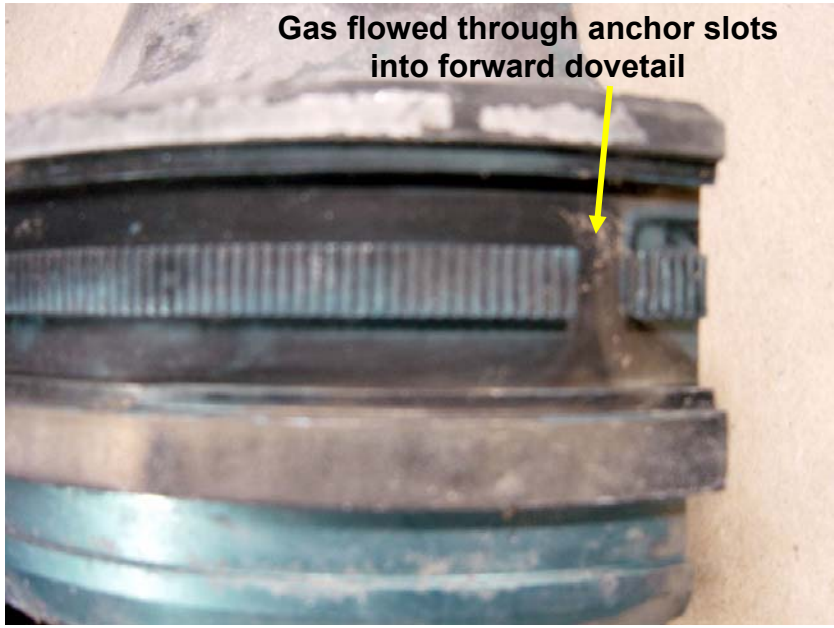
Recovered Sabots – General results

2. Plunge Cut
   - The nylon obturator bands showed very little signs of circumferential tearing.
   - 90% of the bands were completely blown out of the sabot segments. This is typical to what is seen during +52°C and +21 °C.
   - Gas was able to intrude under the obturator bands.



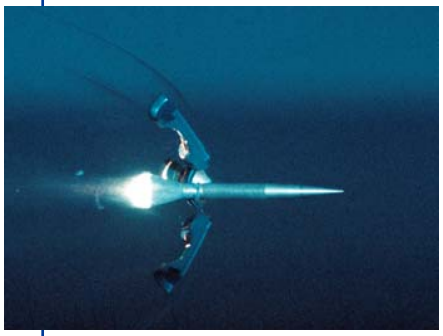
Recovered Sabots – General results

3. Anchor Slots
   - Gas wash intruded into forward and aft dovetail on 95% of the sabot segments. Gas wash flowed through the anchor slots.
   - There was no evidence of band rotation.
   - Designs with this feature on average exhibited an increase in muzzle velocity of 20 m/s.



Conclusions and Path Forward

Design 4 (Plunge cut and Anchor slots) performed significantly better than the current M865 design.



- Significant improvement in TID
- 25% lower rate of fliers than current design
- Increased muzzle velocity by an average of 20 m/s
- Recovered sabot segments exhibited characteristics similar to what is seen after +52°C and +21 °C tests.

Verification testing of Design 4 to take place in June 2005 at YPG.

- GD-OTS and ATK to participate in verification test
- 180 test rounds with 60 control rounds.

Questions

TBX Evaluation Testing in the M151 Warhead as Risk Reduction for the APKWS

Jason Gilliam

2005 NDIA Missiles & Rockets Symposium

28 April 2005

Proposed APKWS "Block II" Objectives

Integrate Technologies to Replace the Current M151 and M423

- Insensitive Munition Compliance Is Main Focus
- Improved Warhead and Fuze Lethality
- Improved MIL-STD 1316 Fuze
- Program Ends in FY05 with TRL 6 Prototype Designs and Supporting Test Data
- Low Risk Transition to APKWS Block II SDD

APKWS Warhead / Fuze Program Overview

- Design for IM
- Enhanced Fragmentation
- Enhanced Blast
- Dual Safe Fuze

Next Step: **APKWS Block II Warhead and Fuze Program Will Provide the Capability to Defeat the Current and Evolving Threat**

AMMPGM STO-Funded Warhead Risk Reduction Activities

Objective: To Investigate High-Risk Areas and Critical Technologies of 2.75" Warhead Development as a Parallel Effort to APKWS

Fragmentation Tests

- M151 Modified With Preformed Tungsten Cubes
- Embedded Fragmentation Warhead

Water Tank Tests

- Complete Fragment Mass Distribution Data
- Easier Data Reduction

Tandem Blast Frag / SC

- Shaped Charge and Blast Fragmentation Tandem Warhead
- Various Configurations

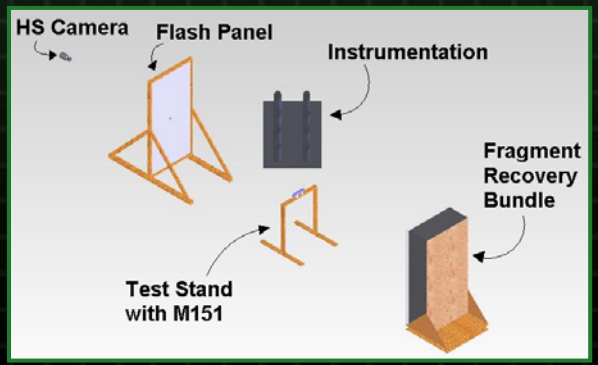
TBX / Enhanced Blast Tests

- Evaluation of Several TBX Fills From Industry
- Pressure, Temperature, and Fragmentation Data
- M151 Warhead Bodies

Thermobarics (TBX) / Enhanced Blast Tests

Objective: Conduct an Evaluation of Candidate TBX Fills from Industry and Other Gov't Agencies for APKWS Warhead

- "Mini" Arena Test Setup
  - One Velocity Panel, One Celetex Bundle
- Evaluation of 14 Different Explosive Fills
- Data Acquisition:
  - Pressure & Temperature
  - Fragment Velocity
  - Fragment Mass and Spatial Distribution
  - Number of Fragments
- Data Will Be Available to Industry
- Evaluate TBX Fragment Driving Capability
- Comp B, PBXN-109, and PBXN-110 Tested as Baselines



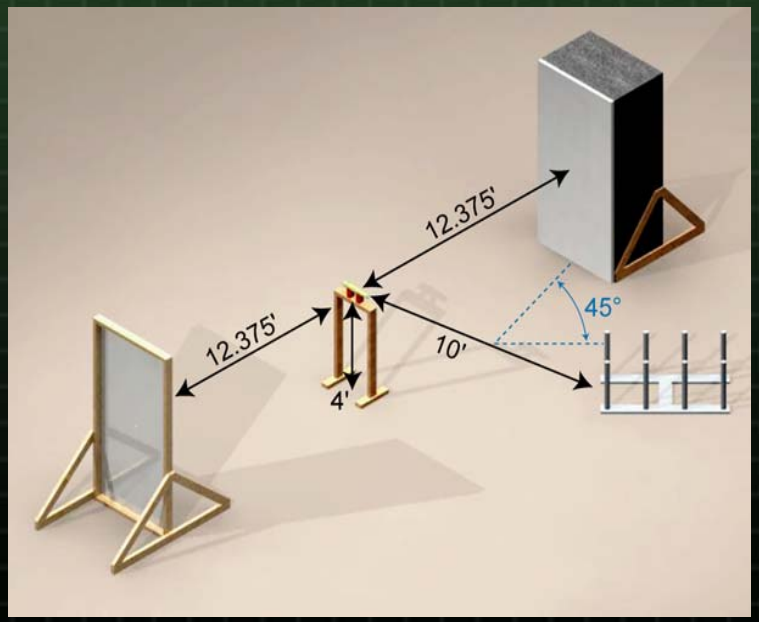
AMRDEC	Comp B
AMRDEC	PBXN-109
AMRDEC	PBXN-110
AMRDEC	RAX-16
Picatinny	PAX-28
Picatinny	PAX-3
EBA&D	YJ-05
ATK	NIX-G
ATK	TEPX-D
Talley	3 fills
Navy	CLAP 1
Navy	C133

M151 Enhanced Blast Test Matrix

Test #	Company/Organization	Explosive Fill	Test Date
1	AMRDEC Baseline (Current M151 Fill)	Comp B	3/17/2004
2	AMRDEC Baseline	PBXN-109	4/6/2004
3	AMRDEC Baseline	PBXN-110	6/2/2004
4	American Ordnance Iowa \ Picatinny	PAX-3	4/20/2004
5	Alliant Techsystems \ Picatinny	NIX-G	4/19/2004
6	Alliant Techsystems	TEPX-D	4/22/2004
7	Talley Defense Systems	7164	5/11/2004
8	Talley Defense Systems	7172	5/12/2004
9	Talley Defense Systems	7174	5/27/2004
10	NAVY (NAVAIR, China Lake)	CLAP	4/28/2004
11	NAVY (NAVAIR, China Lake)	CL133	5/25/2004
12	Ensign-Bickford Aerospace & Defense	YJ-05	4/7/2004
13	ARDEC Picatinny	PAX-28	4/27/2004
14	AMRDEC	RAX-16	4/5/2004

Mini-Arena Test Setup

- Standard M151 2.75” Warhead Body
  - Approx 6.4 lbs (empty)
  - Naturally Fragmenting Cast Iron
- Filled and Returned to Redstone for Testing
- Initiated with RP-80 & Booster at Front
- Comp-B tested as Baseline



- “Mini Arena” Setup
  - 1 Celetex Bundle
  - 1 Alum Velocity Panel
    - Phantom Video
- 4 Pressure Transducers
- 4 Calorimeters
- 4 Thermocouples
  - 45º from WHD Axis

“Mini Arena” Test Video

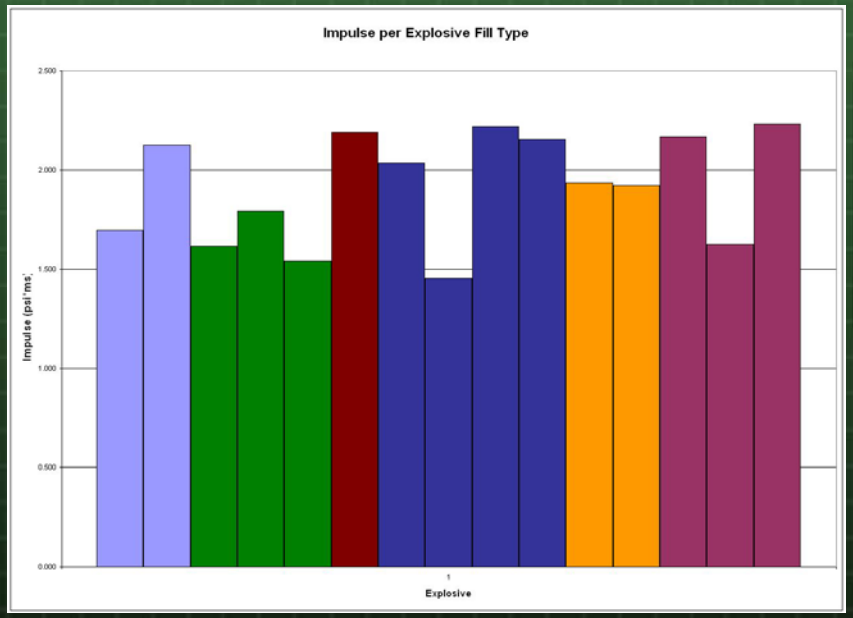
Peak Pressure Measurement

Explosive	Peak Pressure (psi) at 10 feet
A	23.33
B	20.50
C	20.21
D	20.20
E	18.21
F	17.38
G	16.92
H	15.86
I	14.87
PBXN-110	13.88
J	13.34
K	11.44
Comp B	9.91
PBXN-109	9.45

- Peak Pressure Recorded at Closest Pressure Transducer
- 10 Feet from Warhead
- Explosives 'named' A-L Based upon Peak Pressure Data Rank
- Same Nomenclature used for Remaining Comparisons
- Fielded M151 Explosive is Comp B

Pressure Impulse at 10 Feet

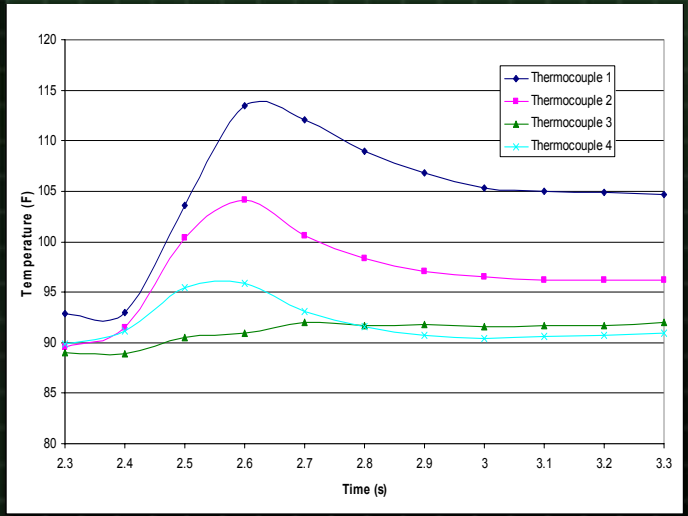
Explosive	Impulse at 10' (psi-ms)
A	2.230
B	2.219
K	2.190
D	2.168
F	2.154
C	2.125
E	2.035
J	1.930
PBXN-109	1.793
G	1.697
H	1.627
Comp B	1.617
PBXN-110	1.540
I	1.455



Baselines

Temperature Data

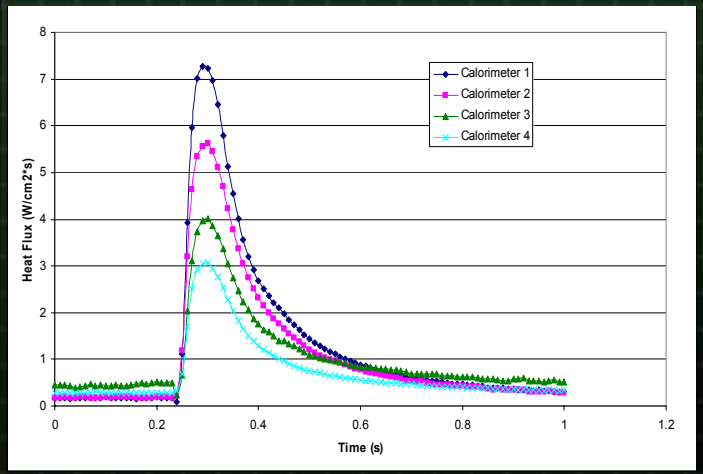
- Temperature Increase Recorded at Closest Sensor
- Pressure and Temperature Effects not on same Trend



Explosive	Temperature Increase at 10' (°F)
J	20.48
H	19.42
PBXN-109	17.82
A	17.24
E	14.87
I	13.39
C	12.14
K	9.50
B	9.17
D	8.86
F	5.16
PBXN-110	Gage Malfunction
Comp B	Gage Malfunction
G	Gage Malfunction

Heat Flux (Calorimeter) Data

- Peak Heat Flux Recorded at 10 feet from Warhead

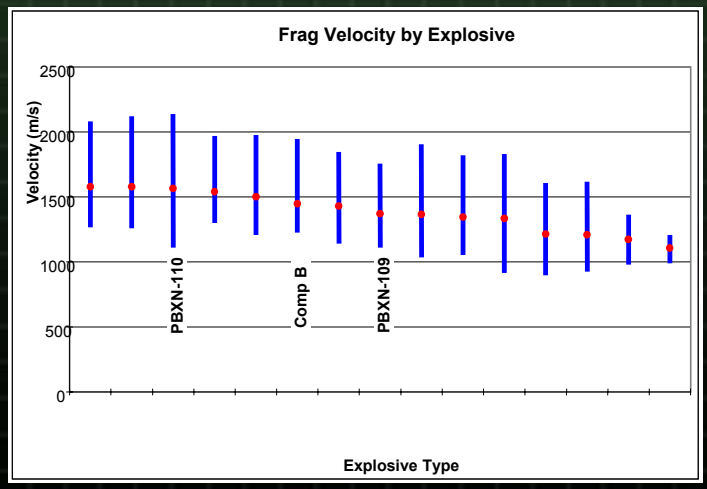


Heat Fluxes	Heat Flux at 10' (W/cm^2-s)
J	7.09
H	5.32
E	4.66
G	4.57
D	3.49
PBXN-109	3.10
F	2.66
K	2.62
A	2.35
B	2.07
C	1.99
I	1.86
Comp B	Gage Malfunction
PBXN-110	Gage Malfunction

Fragment Velocities

Explosive	Average Fragment Velocity (m/s)
A	1580
B	1579
PBXN-110	1566
C	1542
F	1502
Comp B	1449
K	1430
PBXN-109	1372
D	1365
H	1346
G	1336
J	1213
E	1174
I	1109

- Velocities Measured via Phantom High Speed Video
- Min, Max, & Avg Velocities Calculated
- **The Best Performers in Pressure were Also the Best at Driving Fragments**



of Fragment Perforations

Explosive	Number of Perforations
A	564
B	523
PBXN-110	493
C	441
Comp B	396
H	378
F	368
G	347
K	333
J	326
D	324
PBXN-109	315
E	268
I	155

Summary of TBX Evaluation Results

Explosive Fill Rankings	Peak Pressure	Pressure Impulse	Temperature Delta	Fragment Velocity	Fragment Perforations	Heat Flux	Cummalitive Score (Lower=Better)
A	1	1	4	1	1	9	17
B	2	2	9	2	2	10	27
C	3	6	7	4	4	11	35
H	8	11	2	10	6	2	39
F	6	5	11	5	7	7	41
D	4	4	10	9	11	5	43
J	11	8	1	12	10	1	43
E	5	7	5	13	13	3	46
G	7	10	7	11	8	4	47
PBXN-110	10	13	8	3	3	10	47
K	12	3	10	7	9	8	49
PBXN-109	14	9	3	8	12	6	52
COMP B	13	12	10	6	5	10	56
I	9	14	6	14	14	12	69

No Data, (Estimate)

- Each Measured Characteristic Given an even Weighting
- 80% of Candidate Explosive Fills Exceeded Baselines
- Ranking may be different depending on desired application
- This Testing Demonstrated that Many Enhanced Blast (i.e. TBX) Explosives Maintain Adequate Fragment Driving Characteristics

40th Annual Armament Systems:
Guns – Ammunition – Rockets - Missiles

The 81mm Non Lethal **Mo**rtar **Ca**rrier **P**rojectile (MoCaP)

U.S. Army RDECOM-ARDEC (Picatinny, NJ)

Seungeuk Han

Andrew Ponikowski

Raymond Trohanowsky

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Background

♦ In May 1999, the Joint Non-Lethal Weapons Directorate (JNLWD) initiated investigation of the long range delivery of non lethal payloads.

♦ One year later, RDECOM-ARDEC was asked by JNLWD to oversee the program.

♦ RDECOM-ARDEC has been devoted to find ways to meet a Terminal Kinetic Energy Criterion of 58 ft-lbs.

♦ RDECOM-ARDEC team previously demonstrated technical readiness level (TRL) of 4 by using parachute recovery method and commercial (fireworks industry) electronic time fuze.

♦Demonstrated a TRL 5 ➔ Prepared for a Milestone A Decision

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Mission Needs

- Today's non-lethal capability, such as rubber bullets or tear-gas requires soldiers to put themselves in the middle of a crowd to disperse it, thus putting themselves in harms way of potential suicide bombers or improvised explosive devices.
- Current projectile delivery components can impact and injure crowds or property on the ground.
  - Increase risk of riot and negative image.
  - Liable for collateral damage.
- Providing a non-lethal mortar carrier projectile gives the warfighter a capability of crowd control from a stand-off distance.

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MoCaP Meets Mission Need

- Can be fired from an existing weapon system as the conventional munitions without requiring additional training.
- Warfighters have the ability to fire non-lethal and lethal munitions without changing weapon configuration.
- Able to engage combatants with lethal capability while preventing the buildup of concentrations of non-combatants.
- Decelerator system is deployed to bring all the components to the ground to ensure there will be no fatalities from the delivery system.
- The government will minimize liability due to collateral property damage and human casualties.

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Design Requirements

- Range > 2500 meters
- KE < 58 foot-pounds
- Fire from an existing weapon system
- No additional training requirements.

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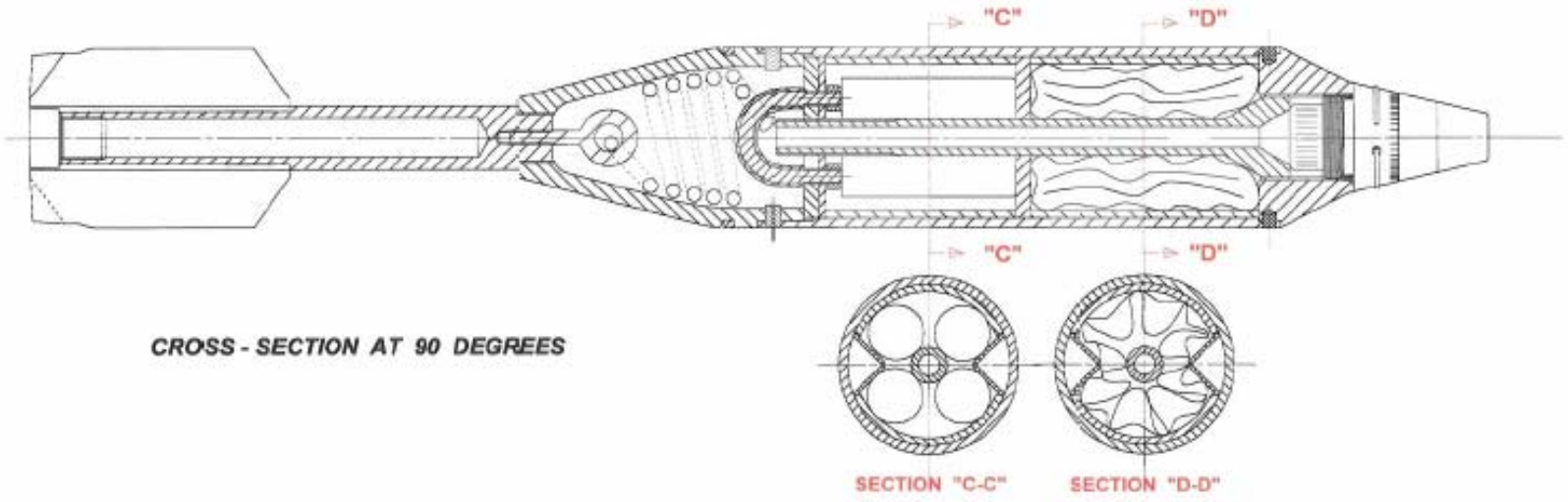
MoCaP Design



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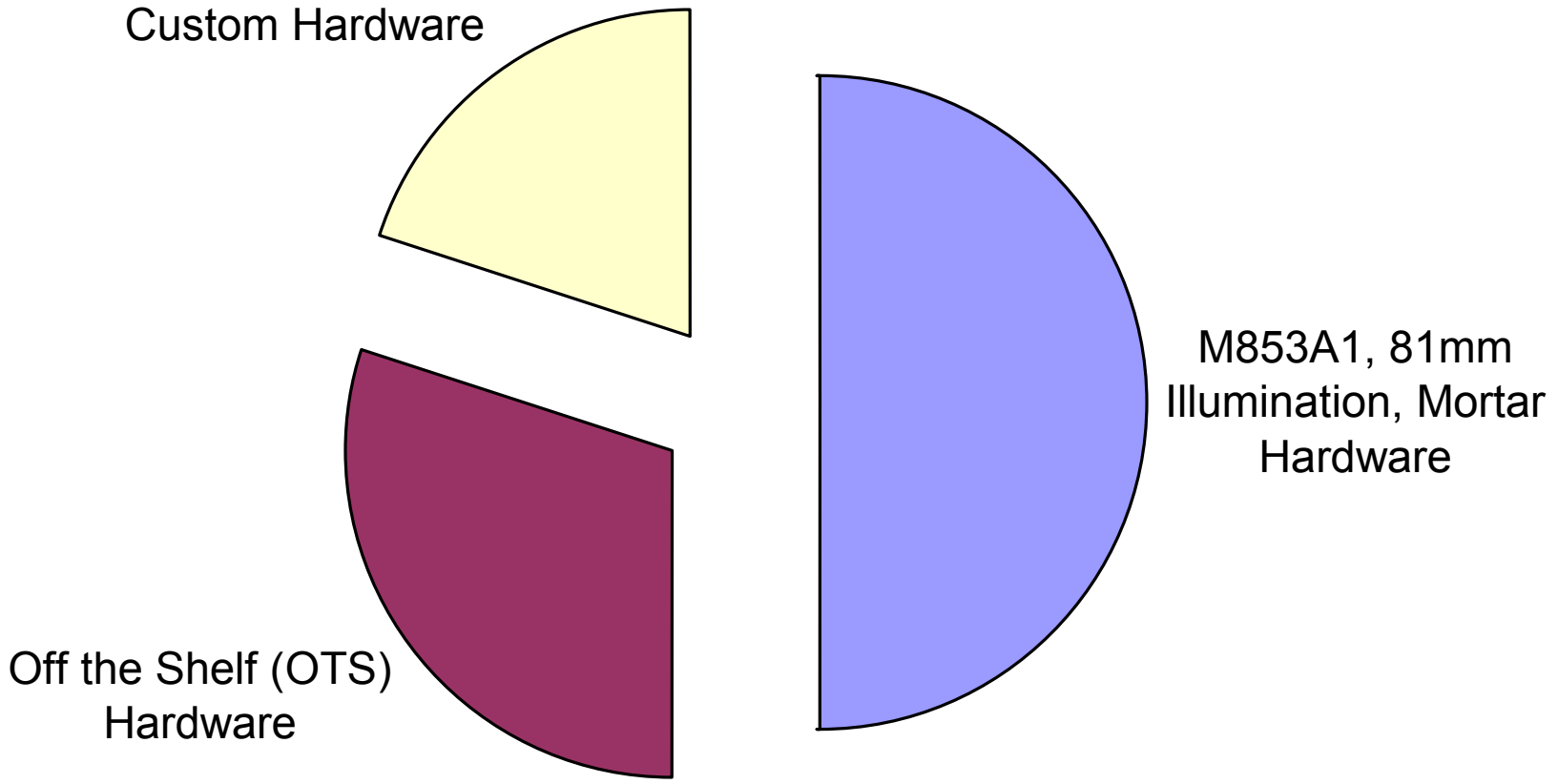
Design Description



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Design Features

- Forward Ejection
- Pressure Tube
- Vent System
- Tethering System
- Dual Parachute System

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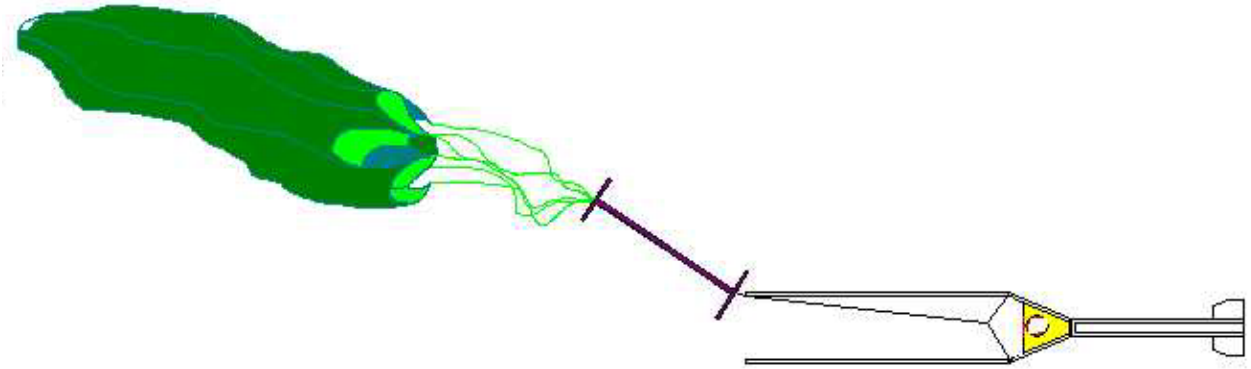
Forward Ejection



- Utilize the ejection concept proven during previous Proof of Principal.
- Utilize an existing fuze for simplicity and provide required stability.
  - Developing a new fuze is a major program that should be avoided.
  - Weight of the fuze is required for static stability.
- Avoid mid-body separation.
  - Ejecting two masses in opposite directions requires stronger tethering which raises packing (volume) concerns.

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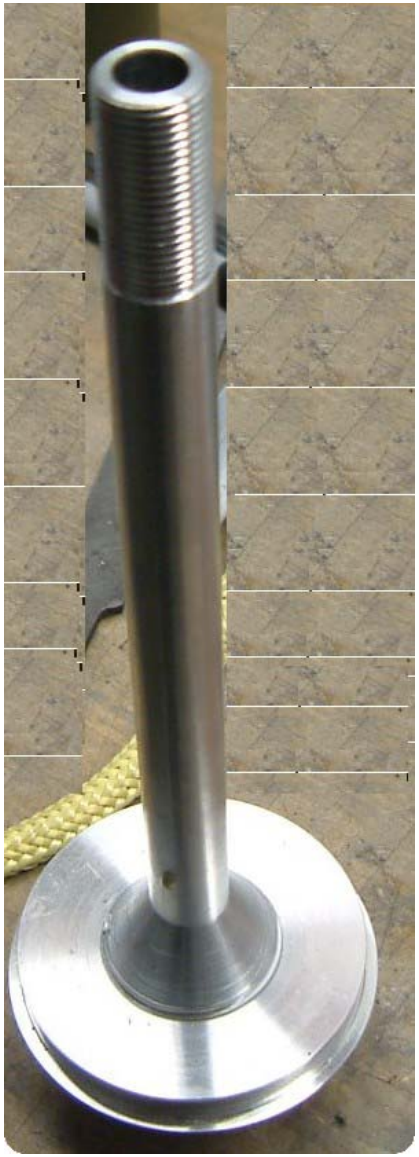
Pressure Tube

- Provide passage to transfer expulsion gas to boattail for rear pressurization.
- Provide structural support to the system.
  - Support the G-force due to the fuze weight during launch – the body can be made lighter (weight reduction potential).
- Riser is looped around the tube:
  - Provide swivel function (leaning system components).
- Lab test completed to determine optimum size.
  - A close bomb test conducted to check: choking & optimum inner diameter of the tube & determine tube thickness.



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Separation Test

- Functioned Fuze to evaluate Performance.
- Results
  - Tethering System failed
  - Need to vent excess pressure

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Lessons Learned

- Observed “Gun Effect”.
- Producibility issues during LAP lead team to develop a modular design for easier assembly.

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Vent System

- Modification of the fuze expulsion charge is not an option.
- Out-of-Box concept to reduce gun effect.
  - Major setback of the design development required major brainstorming.
    - Able to break the four shear pins.
    - Minimize gun effect to reduce force on the tethering system.
    - Optimize payload volume.
    - Provide reasonable volume for parachute system.
- Performed DOE to determine best venting size.

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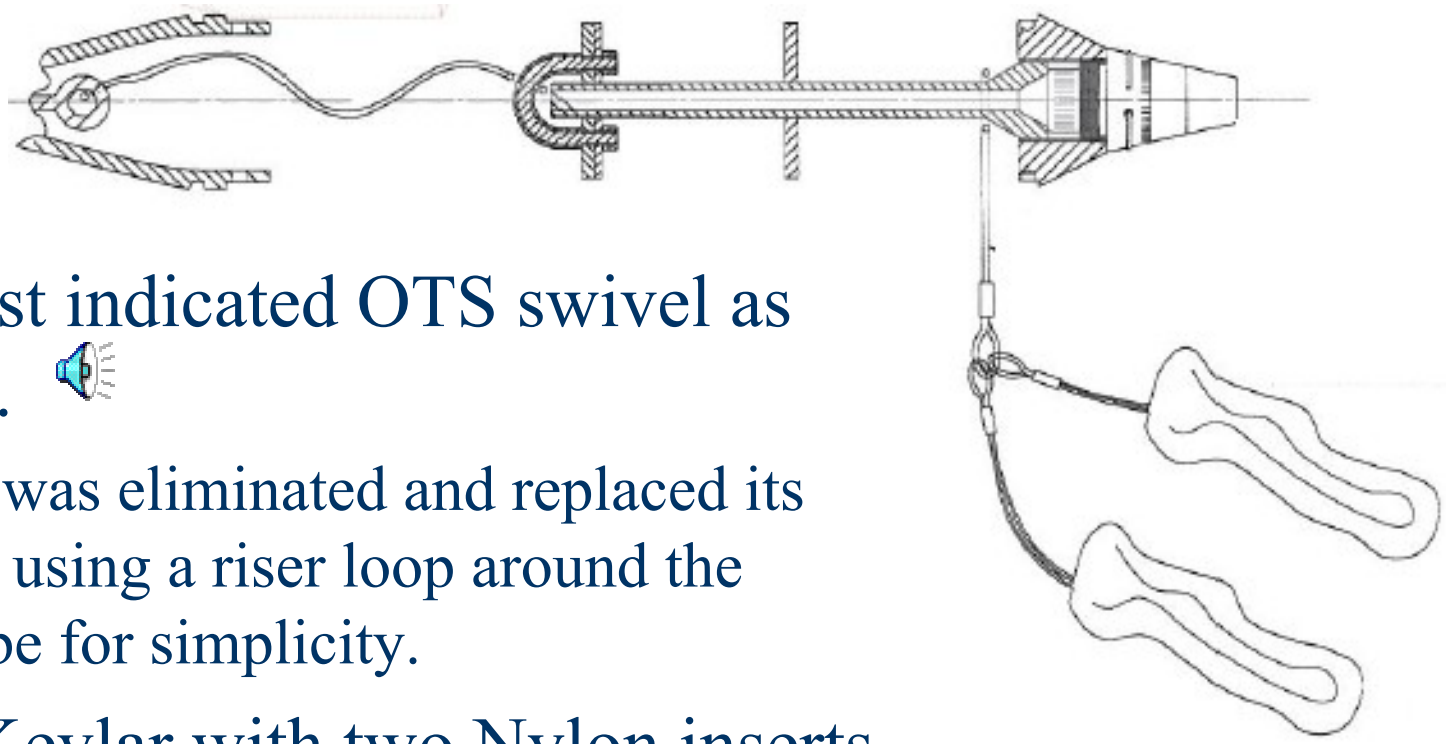
Tethering System



- Static pull test indicated OTS swivel as weakest link.
  - The swivel was eliminated and replaced its function by using a riser loop around the pressure tube for simplicity.
- Reinforced Kevlar with two Nylon inserts.
  - Nylon inserts were designed and reserved to break to dissipate energy upon an excessive force condition.

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Dual Parachute System

- Utilize given volume.
  - Two parachutes were the best option due to two vent tubes on sides and one pressure tube in the middle.
- Increase Reliability.
  - The chutes are independent of each other; increase reliability.
- Meet KE requirements
  - Successful opening of the two small chutes in the design is sufficient to meet 58 ft-lb KE requirements.

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Ballistic Firing

- Demonstrated Range > 2500 m.
- Successfully deployed payload and decelerator.
- Met KE requirement.
- Previously fired from the existing 81mm M252 Mortar System.
- Demonstrated TRL of 5.

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Possible MoCaP Variants

- Flash-bang
- Malodorant
- Acoustic (Screamer)
- Sensors
- Beacon (Transmitter)
- Jamming System
- Liquid Tagging / Marking
- Location Marking
- Battle Damage Assessment
- Surveillance Imaging
- MEMS Delivery

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MoCaP Points of Contact

- Seungeuk Han
  seungeuk.han@us.army.mil
  973-724-2978
- Andrew Ponikowski
  andrew.ponikowski@us.army.mil
  973-724-6945
- Raymond Trohanowsky
  raymond.trohanowsky@us.army.mil
  973-724-7865

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Improvements to Airborne Ladar Man-in-the-Loop Operations

Sarah J. Hard, Joseph E. Grobmyer, Jr., Tommy Lum,
Robert E. Morris, H. Lee Pratt
U.S. Army RDECOM, AMRDEC
Cliff Andressen
Raytheon Missile Systems
Redstone Arsenal, Alabama

28 April 2005

Outline

- Objectives
- Test Description
- Results
- Analysis
- Conclusions

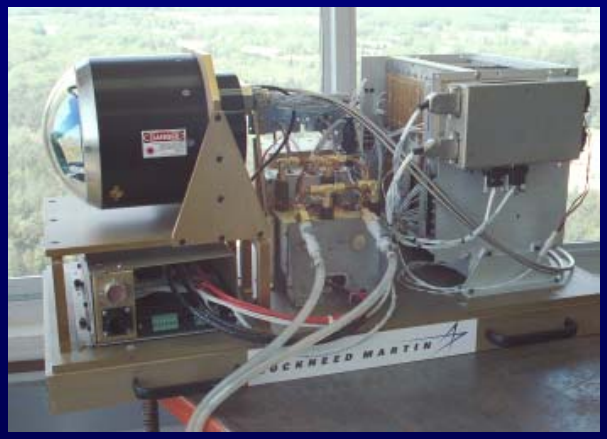
Ladar Visualization and Analysis (LAVA) Test

Objective:

- Collect Ladar imagery over UAV type scenarios
- Improve visualization processes and techniques employed by UAV sensor technology

Approach:

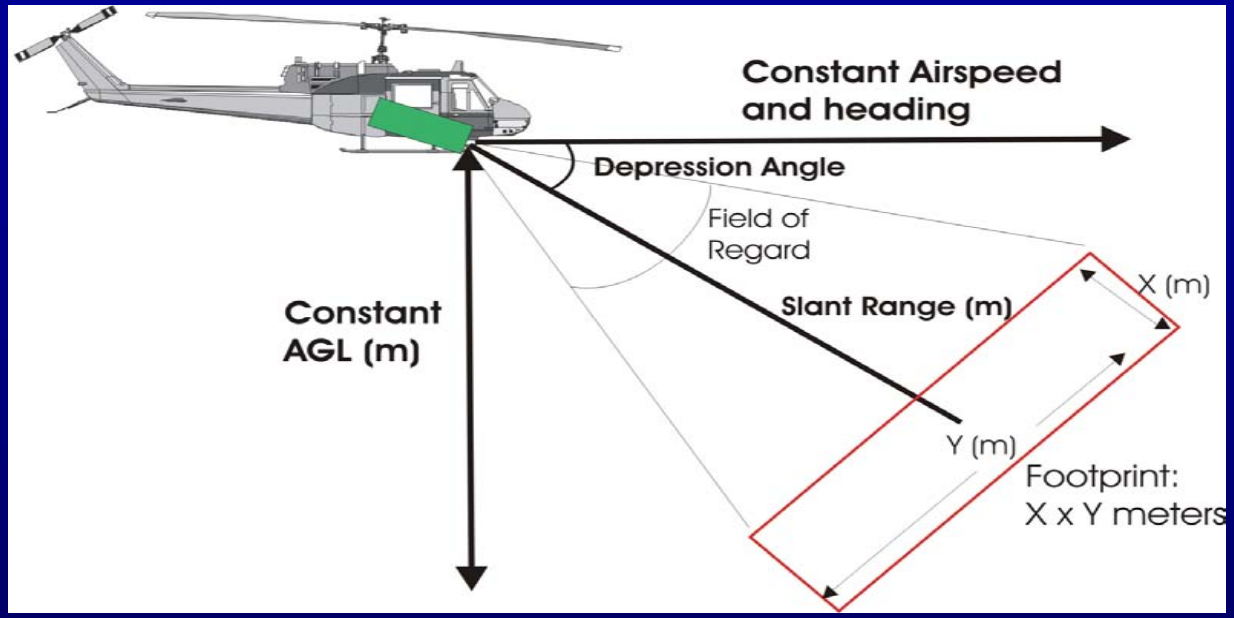
- Conduct captive flight test (CFT) utilizing the Lockheed STAR Ladar seeker
- Collect Ladar imagery over RSA and surrounding urban area

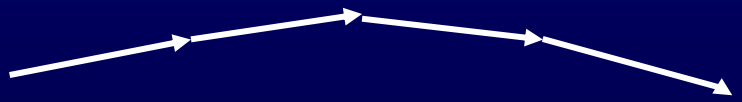


Payoff:

- *Provide additional dataset to improve man-in-the loop operations and ATR development for UAV tactical environments.*

Test Description





Waypoint Flight Path

	Flight Configuration #1	Flight Configuration #2
Speed	50 kts	50 kts
Altitude (AGL)	2121 feet	3182 feet
Sensor Depression Angle	45°	45°
Sensor Slant Range	1000m	1500m
Sensor Scan Footprint	59m x 436m	89m x 655m
Sensor FOR	25 deg	25 deg
Spot Size at Range	40cm	60cm

LADAR CFT Data Collection Areas

Test Area 3, RSA

Building 5400, RSA

RMF, RSA

Whitesburg Bridge, HSV

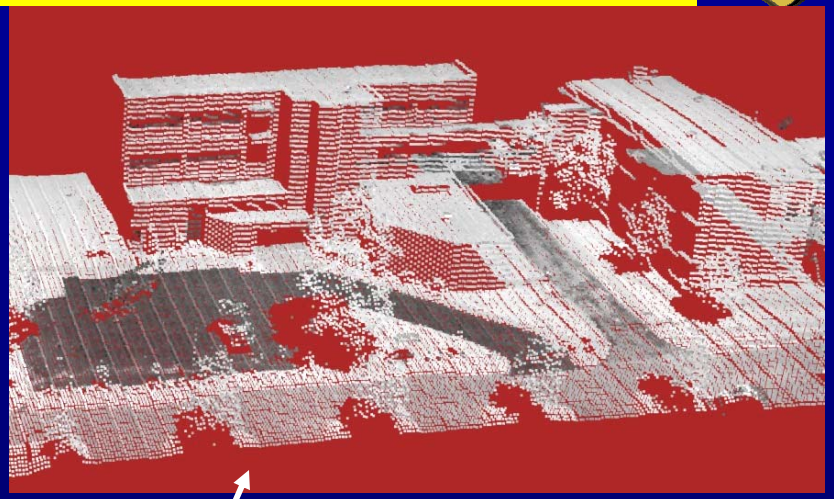
US Hwy 231, HSV

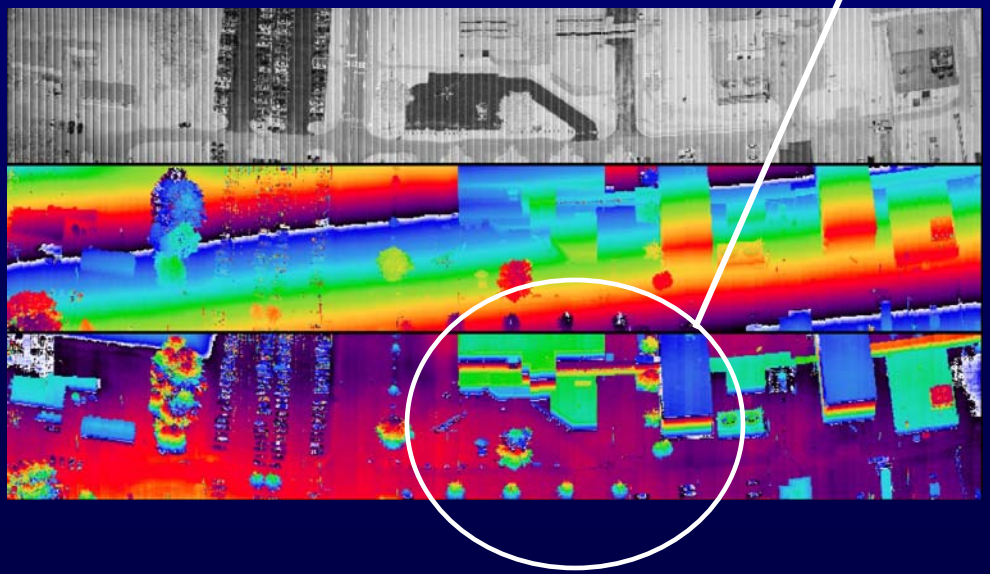
Space/Rocket Ctr, HSV

I-565, HSV

Data Results / Examples from CFT

Building 5400, Redstone Arsenal, AL



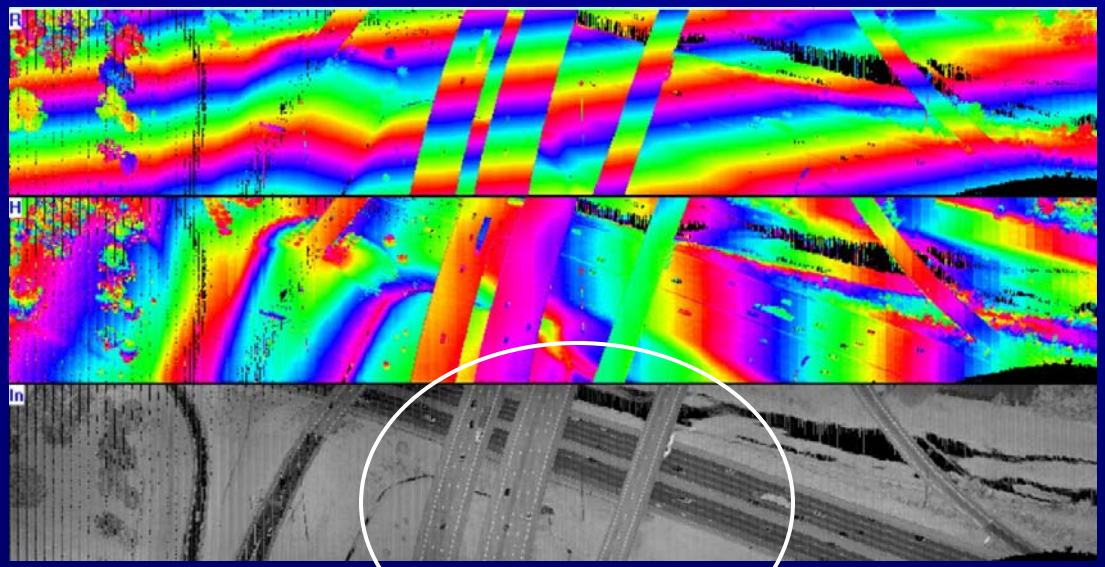


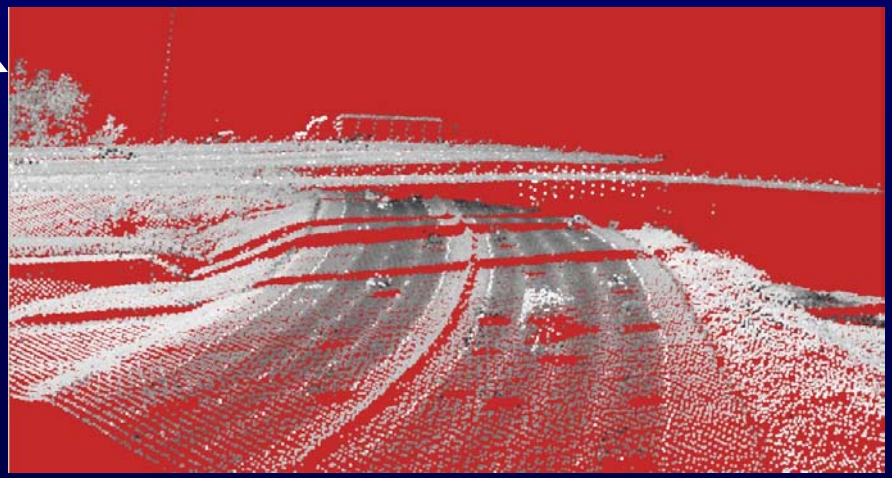
Intensity

Range

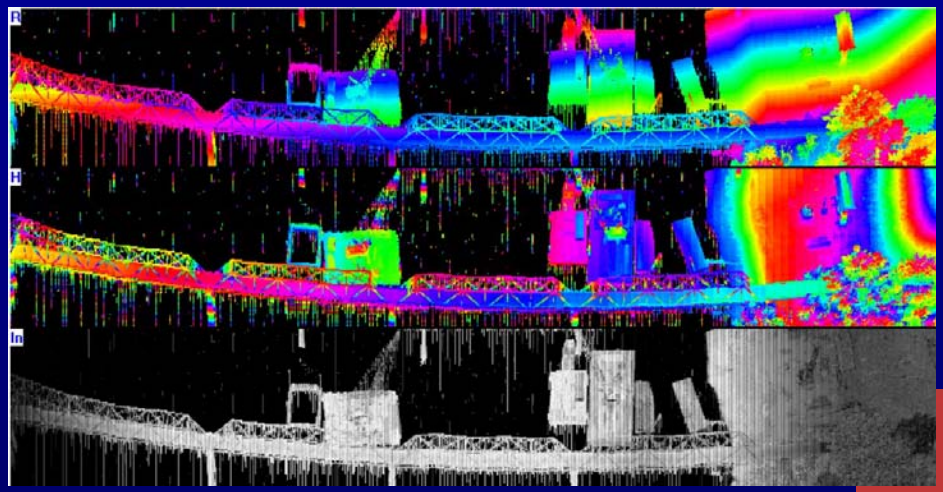
Height

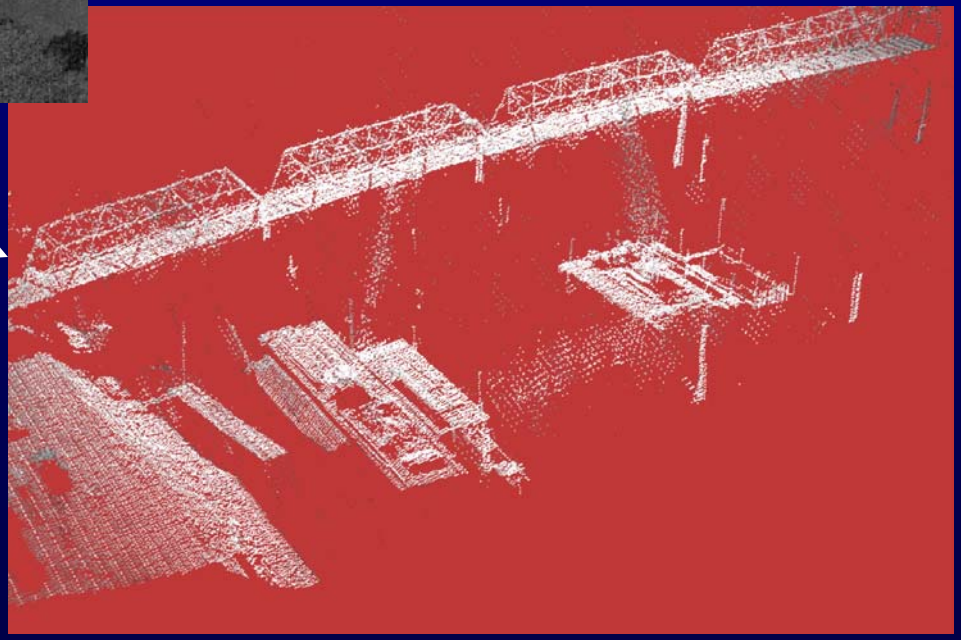
I-565 over Highway 231, Huntsville, AL





Whitesburg Bridge, Huntsville, AL





Reverse Angle

Raytheon

CLAS Test Summary

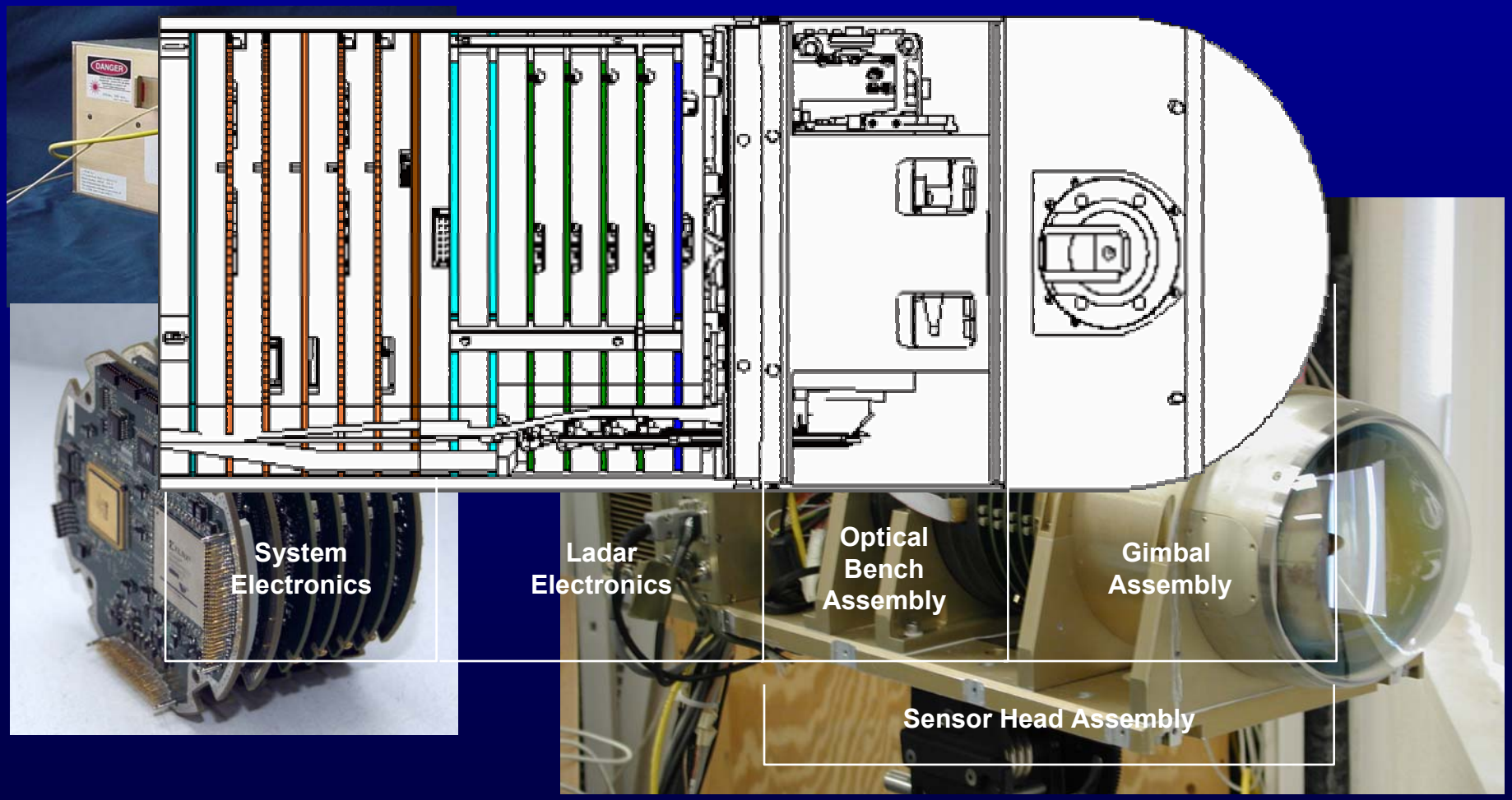
- Test designed for advanced LADAR ATR algorithm development
- Data successfully collected for all test scenarios
  - Targets imaged from less than 250 meters to over 4 Km
- 3 Days, ~20 scenarios, thousands of images
  - Moving, confusers, long range, variable resolution, stationary, clutter, camouflage, dismounts, urban data
- System was operational in < 2 hrs after arrival on site
  - No failures in 2 weeks of CY2004 testing and significant transport

Raytheon

DASSL CMRTR LADAR Team Raytheon NetFires Flash

Common LADAR Seeker (CLAS)

ASGE



Raytheon

Russell Measurement Facility (RMF) Laboratory Tower

Top Laboratory Height (from ground to floor): 300 feet

Total Tower Height: 329 feet

Floor Dimensions: 34 x17 feet

Elevator Laboratory
Floor Dim.: 10x6 ft.
30 floor stops

Raytheon

Data Results / Examples from Tower Test

Raytheon

Whitesburg Bridge

Range

Intensity

Target imaged during degraded weather conditions

Raytheon

DASSL CMRTR LADAR Team NetFires Flash

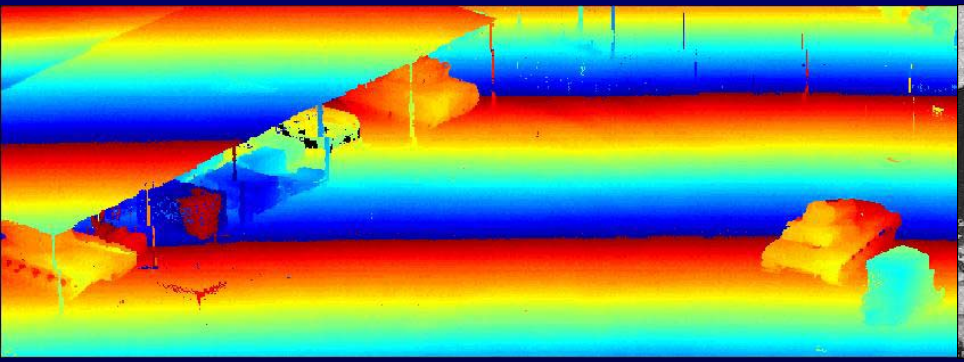
RMF Compound Test Area

ASGE

Data Collection at short range:

- **< 250 meters**
- **Targets in occlusion or open**

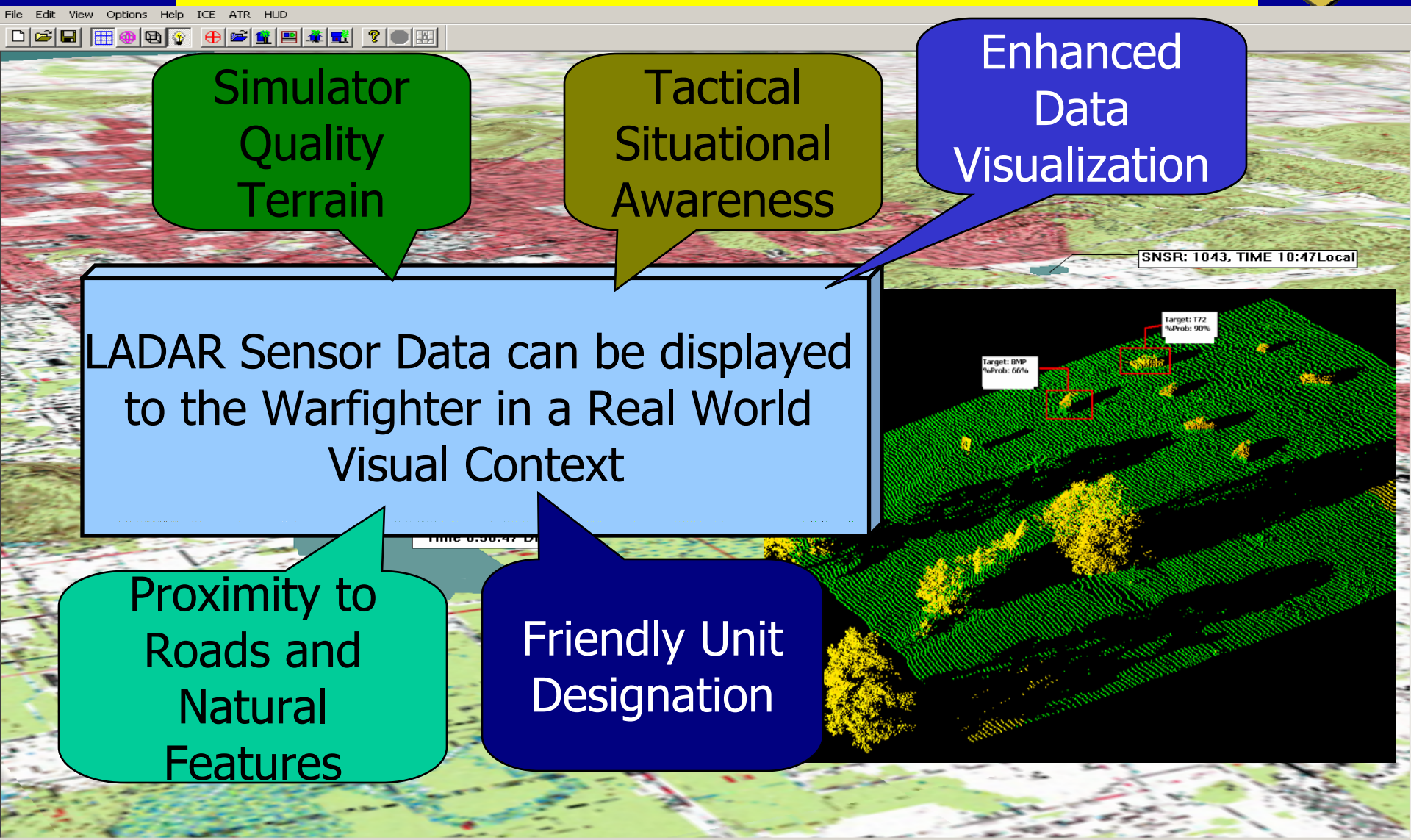
Range Image



Intensity Image

Conclusions

Ladar Data in a World Context



Aviation & Missile
AMRDEC
Strength Through Technology
RDEC Center

ASGE

Questions?

Talley Defense Systems

Fiber Innovations inc.

Development of Composite Launch Tubes for Shoulder Fired Weapons Through Applied Science, Planning and Teamwork

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Background - Why Composites?

- **User Requirements demand new technologies without sacrifices to basic system requirements**
- **Some new technologies increase demands on system components**
- **Must always consider cost**

- **Example: Fire From Enclosure (FFE) capability driven by MOUT requirements, and desire to increase user safety**
  - FFE technologies can greatly increase internal system operating pressures
  - Increased operational loading requires stronger system components
  - Basic system requirements often “fixed”…provide greatest user mobility
    - Length
    - WEIGHT!
  - Cost of single shot (disposable) vs. reusable system

Composites are Key to Meeting critical Strength-to-Weight requirements!!!

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Talley Defense Systems

- **Specializing in:**
  - **Application and integration of launcher, propulsion, and warhead technology for affordable systems.**

- 100% Employee Owned
- Mesa, Arizona - 540 Acres
- 230 Employees
- Field Offices:
  - Ft. Walton Beach, FL
  - Ashville, SC
  - Washington, D.C.
- 95% DOD Business
- Small Business Classification by DOD
- ISO 9001:2001

- **Applications:**
  - **M72 LAW**
  - **BDM/SMAW-D**
  - **SMAW HEDP**
  - **SMAW-NE**
  - **Confined space variants**
  - **Thermobaric variants**

Product Lines

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Composite Structures for the Aerospace, Defense and Commercial Industries

- ***Lockheed Martin Preferred Supplier Award in 2003***
- ***Talley Defense Systems SMAW-HEDP Supplier Award for 2001***
- ***Lockheed Martin Supplier of the Year Award for 2001***

FII Key Processes

- Braiding
- Dry Fabric Lay-up
- Stitching
- RTM
  (Resin Transfer Molding)
- VaRTM
  (Vacuum Assisted
  Resin Transfer Molding)

Walpole, Massachusetts

- FII Founded in 1984
- Small Business
- Development and Production
- 80 employees
- 50,000 Sq. Ft
- AS 9100 / ISO 9001

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Critical Steps in Design with Composites

- **Form team with strong relationship that understands requirements**
  - Team = Customer, Contractor, Supplier
  - Requirements = weight, length, internal operating pressures, handling, environments, safety factor methodology, etc.
- **Establish development process**
- **Ensure team members understand expectations**
- **Turn requirements into design**
- **Demonstration testing**
  - Hydrostatic burst
  - Dynamic burst
- **System level testing**
- **Process validation/qualification**
- **Structured problem solving plans**
  - DOE
  - FRACAS

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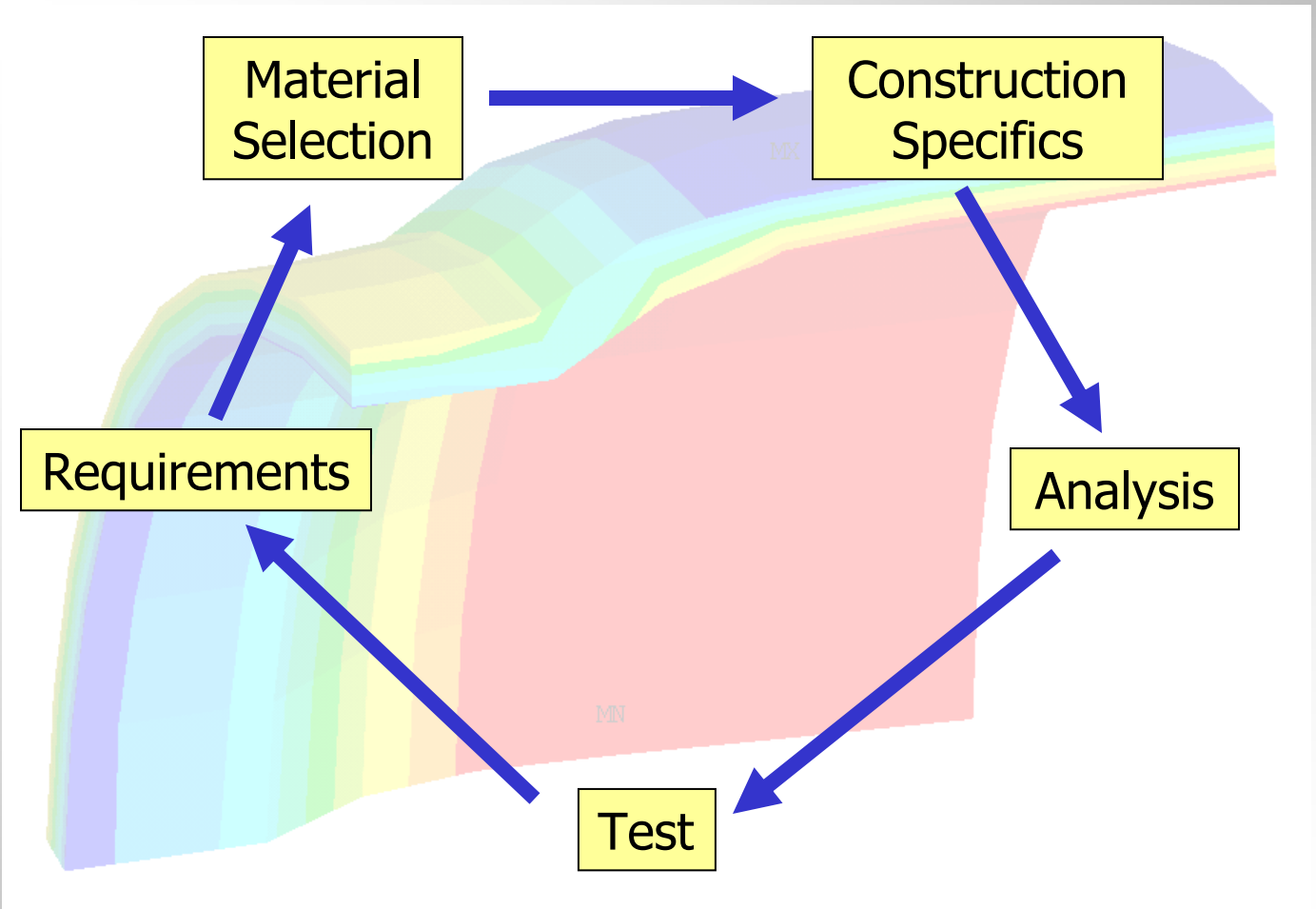
Turning Requirements into Design



- *Above loop allows verification, feedback and iterations throughout design process*

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Requirements Flow-down

- **Customer Level Requirements**
  - Fire From Enclosure
  - System carry Length and Weight
  - System Range/Accuracy
  - Operational Environments
  - Method for Safety Margin Calculation
    - ITOP 5-2-619, Appendix B
    - “Traditional” 1.5X
  - Cost
- **System Level Requirements**
  - Sound and toxicity levels
  - System Length and Weight
  - Projectile velocity and required ballistics to achieve
  - “Furniture” and interfaces required
- **Launch Tube Requirements**
  - Burst pressure requirements, including safety factor
  - Axial strength and stiffness
  - Length and weight of tube(s)
  - Interface/attachments for other components
  - Environments and temperatures

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Baseline the Tube Design

- **Materials Selection**
  - Fiber - Kevlar, Glass, Carbon
    - Strength and Stiffness vs. Weight
    - Cost and Availability
  - Resin - Epoxy
    - Operating temperature and Toughness
    - Production Rate - cure time and temperature
- **Braid Construction**
  - Braid angle / Percentage of axial (0 degree) fiber
  - Fiber tow size / Number of tows (braider size)
  - Fiber volume
  - Resulting Ply thickness
  - Overall structure wall thickness
    - Variable wall allowed based on requirements?
    - Local optimization allows weight reductions
    - Cost effective?

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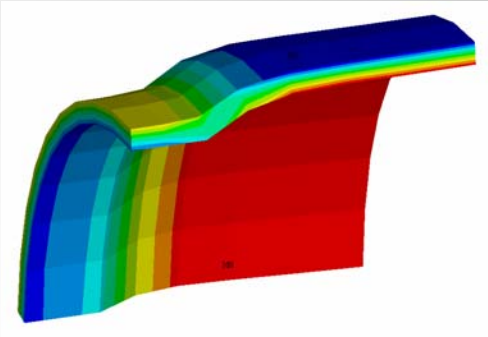
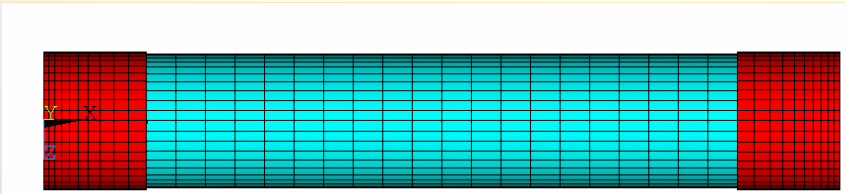
Analyze the Tube Design

- **Why analysis?**
  - Predicts composite structure performance prior to hard investment
  - Provides understanding for design variables and their impact on performance
  - Part of planned, organized development process



- **Types of Analysis**
  - Laminate calculation
    - Estimate of capability for baseline design construction
    - Hand calculation with bulk property estimation
  - FEA Modeling
    - Detailed model of each layer within ply (plus / zero / minus)
    - Application of expected system load profile
      - Static component condition
      - Dynamic component condition
      - Test condition



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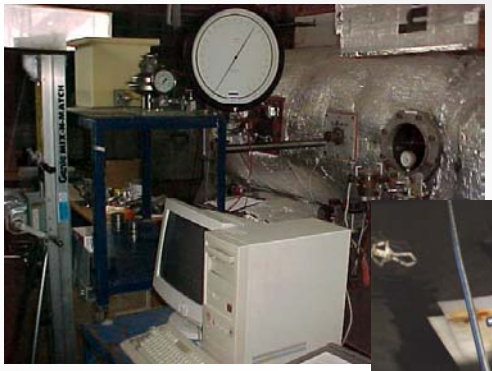
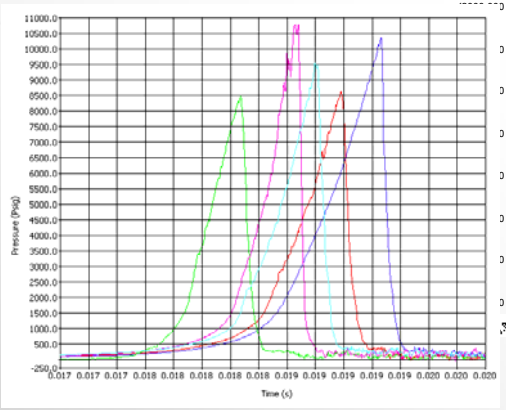
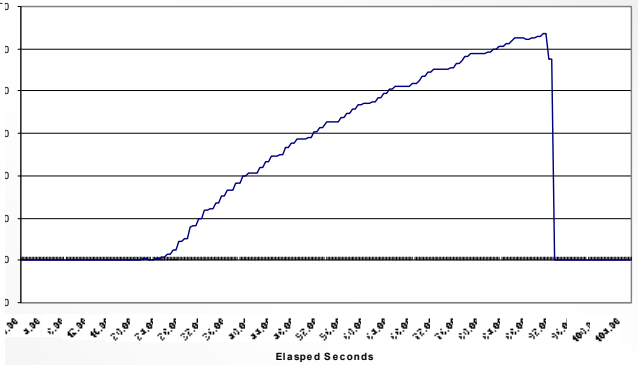
Testing the Tube Design

Testing validates the Analysis, verifies compliance with operational load requirements & provides method for manufacturing control

- **Test Configuration**
  - Specimen length
  - Restraint
- **Fixture Design**
  - End Sealing
  - Ease of use – simple
- **Pressurization**
  - Rate of application
- **Data Collection / Analysis**
  - Sample rate
  - Standard deviation
- **Test Type**
  - Hydrostatic Burst
  - Dynamic Burst
  - Low Pressure Leak
  - System Level







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Validate the Design and Process

Team establishes the pathway to validation and qualification of the launch tube manufacturing process

- **Manufacturing Development Plan (MDP)**
  - Process Flow Diagram
  - Establish cycle time
  - Establish equipment and facilities requirements
  - Identify manufacturing risks
- **Quality Management Plan (QMP)**
  - Supplier internal quality plan - product specific
  - Identify process control items and methods for inspection
    - Dimensional
    - Hydro Burst
    - Leak
  - Establish accept / reject criteria
  - Establish Qualification, First Article and LAT requirements

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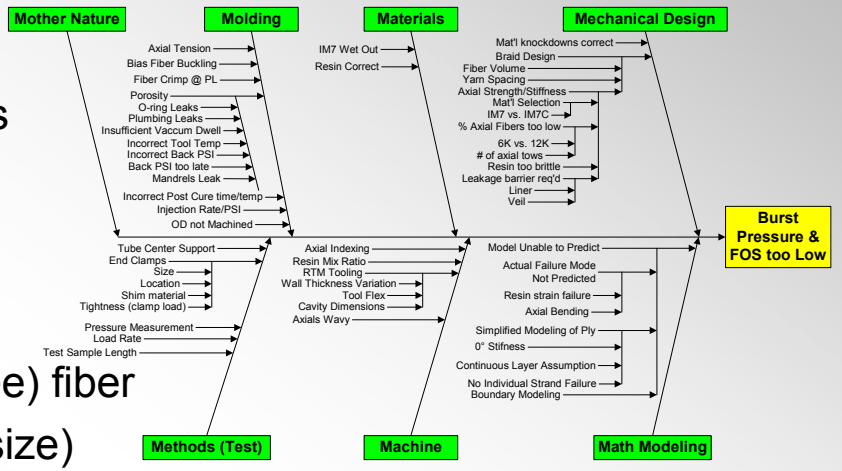
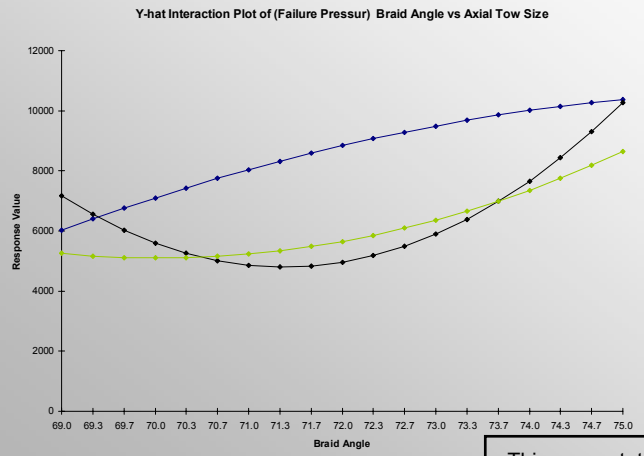
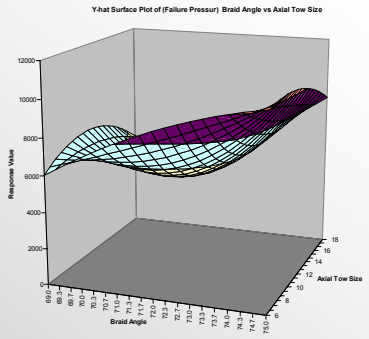
Problem Solving

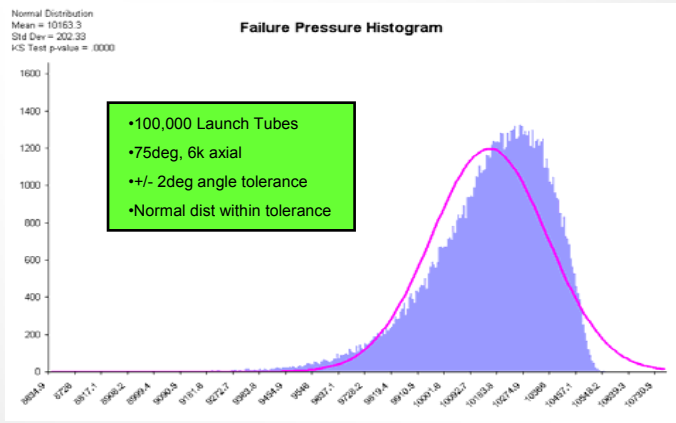
Problems can and will happen. Teamwork and a structured approach mitigates the time and $$$ required to solve them.

- **FRACAS**
  - Well suited to tube manufacturing process
  - Identification of root cause
  - Implement and test corrective action
- **DOE (Design of Experiments)**
  - Braid angle / Percentage of axial (0 degree) fiber
  - Fiber tow size / Number of tows (braider size)
  - Performance predictions









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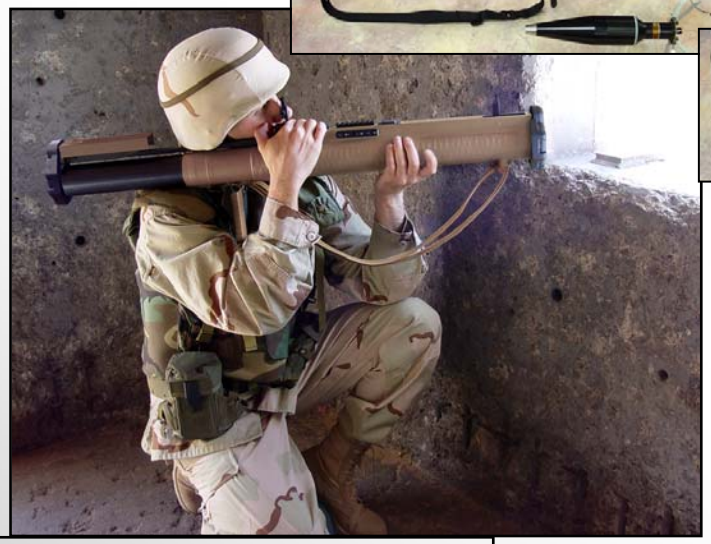
Examples of Success

- **USMC SMAW-HEDP**
  - In production since 1982 (TDS/FII since 2000)
  - Approx. 40,000 units produced at FII
  - Braided, 2-ply Fiberglass
  - Burst pressure standard deviation within 3%

- **NSWC M72E8-FFE**
  - Ground up development
  - Braided, 4-ply Carbon Fiber
    - Thin-wall
    - Light weight
    - In excess of 10,000psi burst
  - Tube qualification in process
  - System IOC 2006 - 2007



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Metal Injection Molding of Wing/Flaperon

BAE Systems, NCDMM, U.S. Army and Polymer Technologies

Jerry C. LaSalle, Director of MIM Operations

Polymer Technologies, Inc (PTI)
10 Clifton Blvd
Clifton, NJ. 07011
973-778-9100

April 28, 2005

This presentation made possible by the

United States Army
Army Material Command (AMC)
Research, Development and Engineering Command (RDECOM)
Aviation and Missile Research, Development and Engineering Center (AMRDEC)
Engineering Directorate (ED)
Manufacturing Science and Technology Division (MST)
Redstone Arsenal, Alabama
Scott A. Hofacker, PE – Program Manager (256) 842-7992

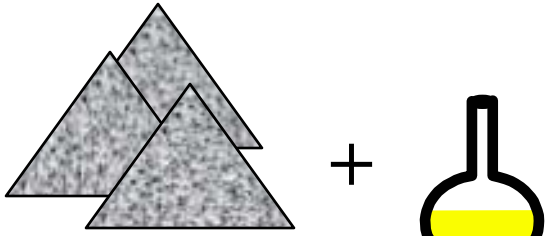
and the

National Center for Defense Manufacturing and Machining (NCDMM)
Latrobe, Pennsylvania
Mark F. Huston – Executive Director (724) 539-8132

Polymer Technologies Inc

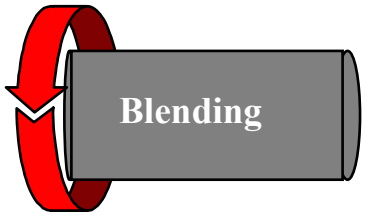
- Started under the name of PTI in 1941. Was spun-off into Polymer Technologies Inc in 1987 to pursue value added, specialty work.
- Occupies 93,000 sq feet. Capable of expansion to 143,000 if needed
- Employees- 95

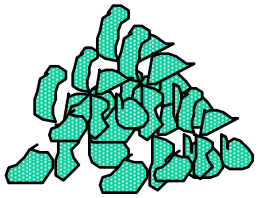
What is Metal Injection Molding?



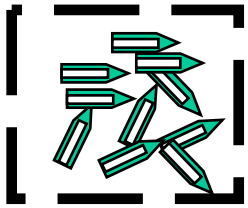
Metal Powders + Binder

Injection molding Feedstock





Injection Molding



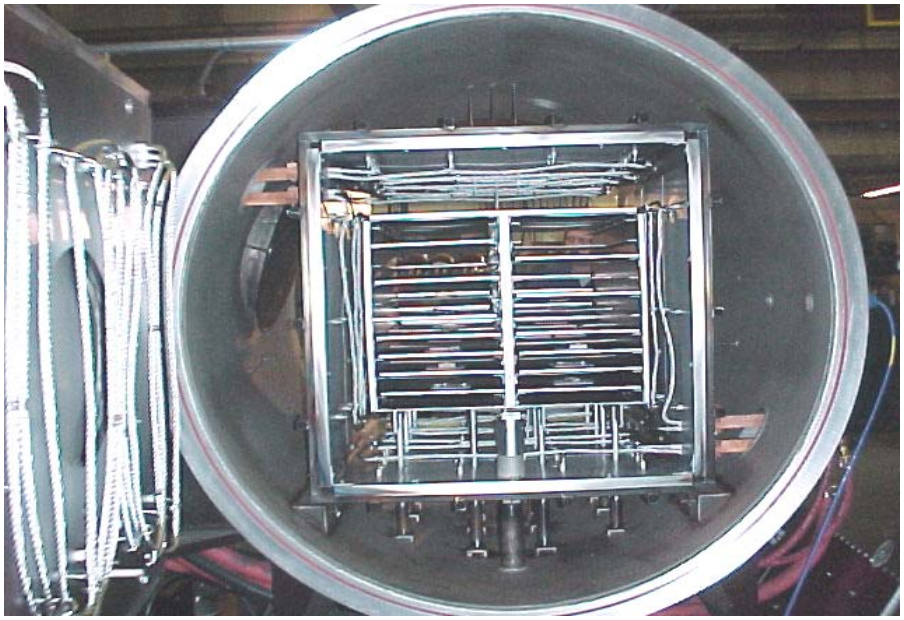
Debinding of Molded Parts

Sintering

150 ton tie-bar-less Injection Molding Machine at PTI

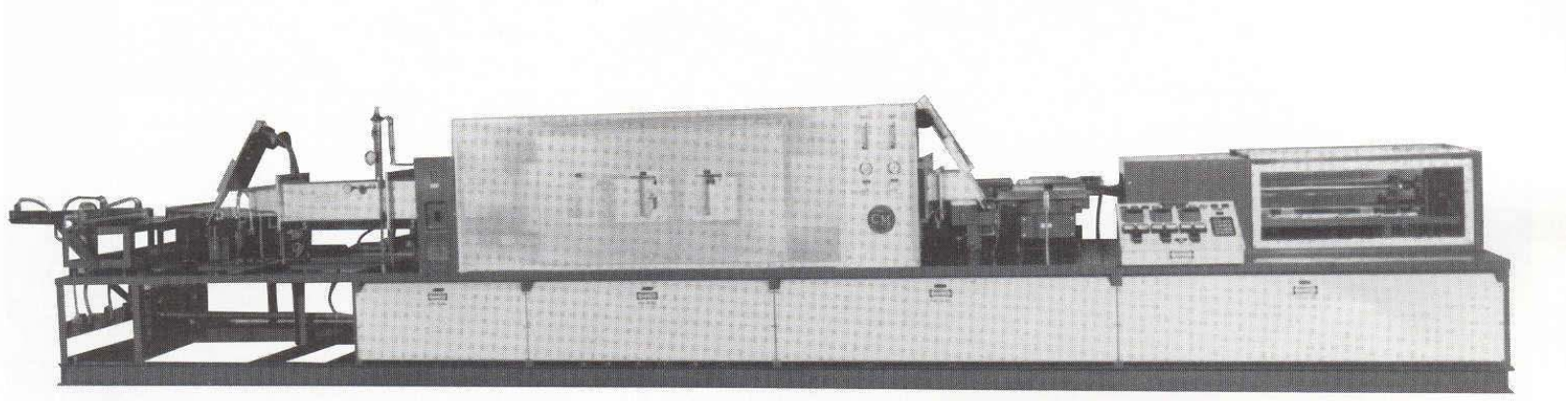
AVS Batch Furnace at PTI

High Vacuum, all metal hot zone for clean rapid cycles



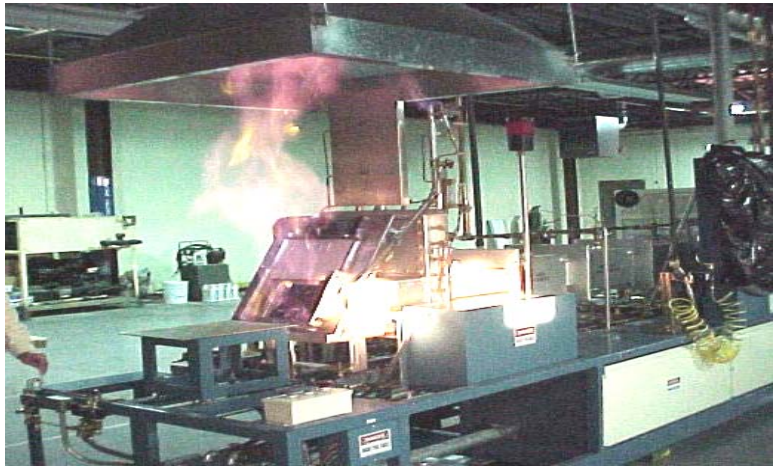
Hydrogen, Argon, Vacuum cycles to 1450°C

Hydrogen Pusher Furnace at PTI



300 Series Model 366 Automatic

- High Production Rate Furnace
- 144” Preheat, 72” high heat, 96” cooling
- fully instrumented
  - (H_2 and N_2 mass flow meters, etc)
- 1650°C (~3000°F) operating temperature



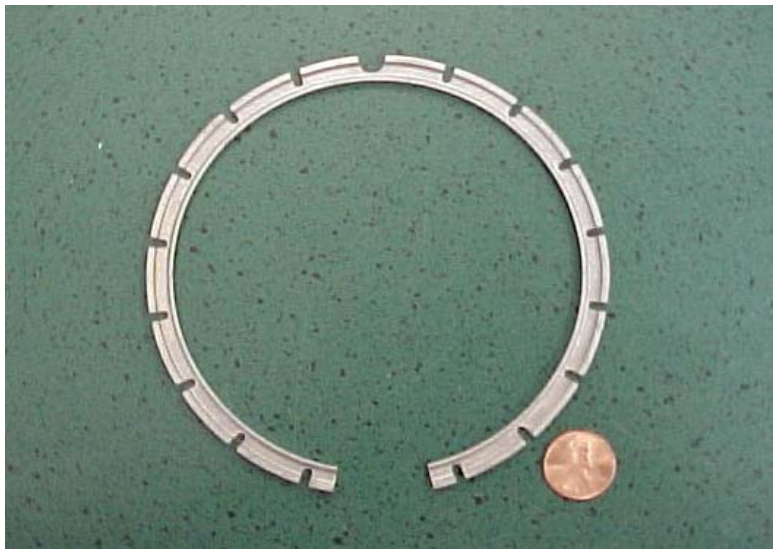
CM Furnace for continuous production

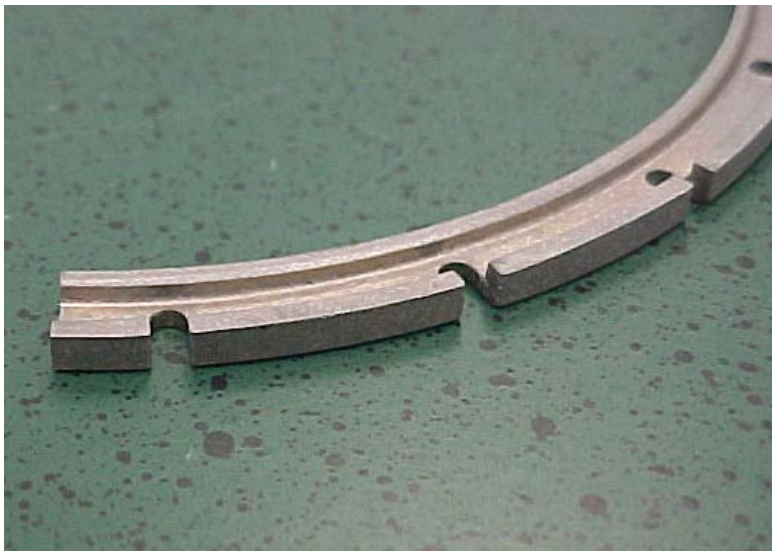
RR195 Backing Plate

MIM 316L

17-4PH Stainless Steel Snap Ring

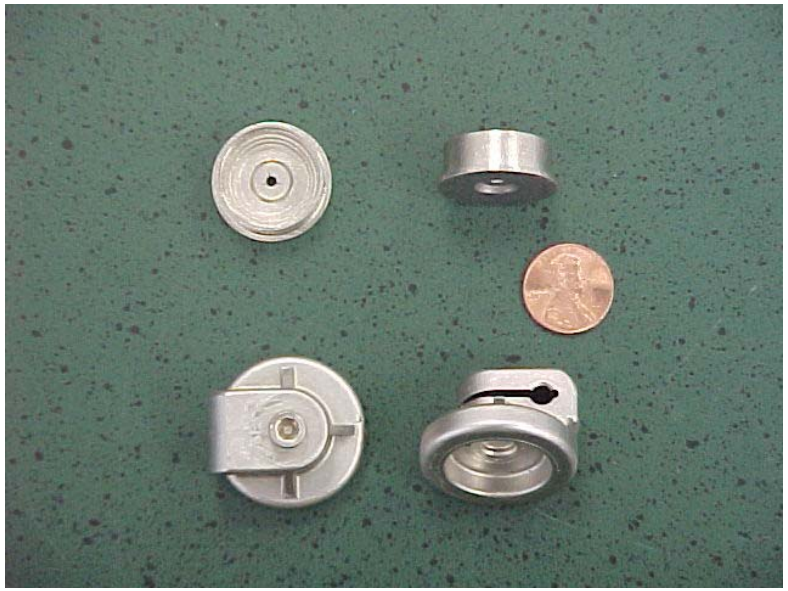
Flying Bomb Housing





Demonstrated ability to flow and fill long thin parts having detail

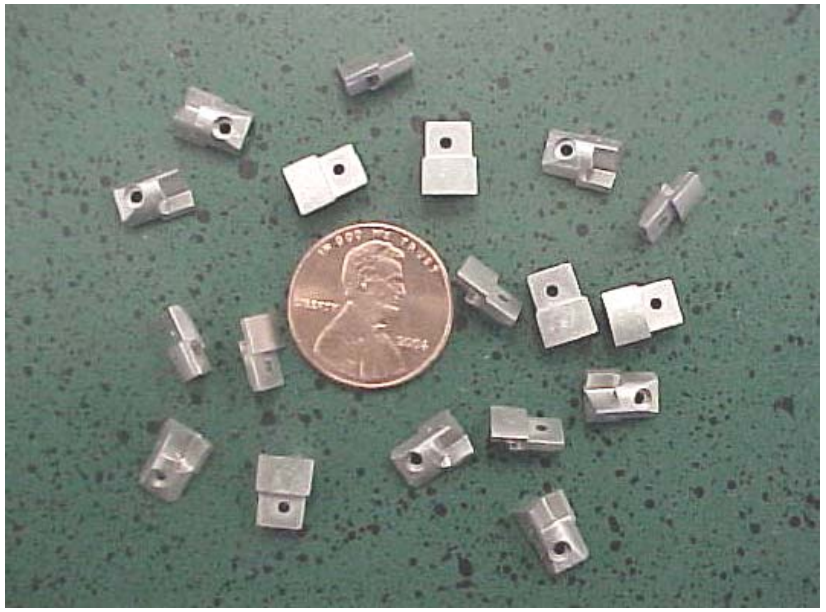
316L, 17-4PH and 4340 Components



Simple and Complicated shapes can be formed easily

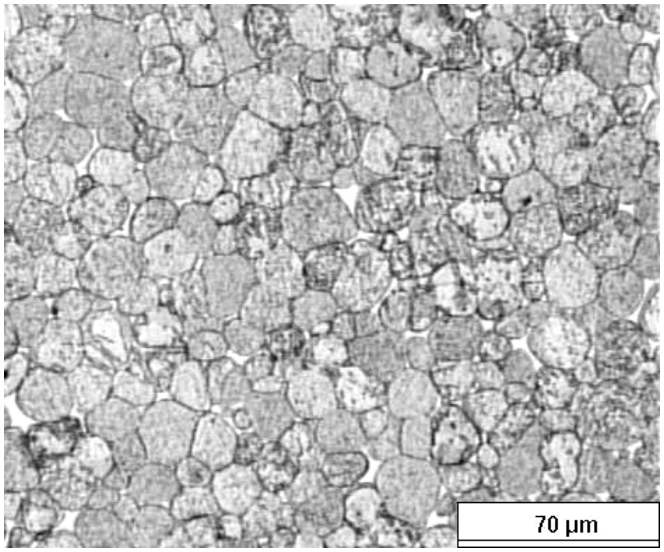
Tungsten Alloy Components

Balls

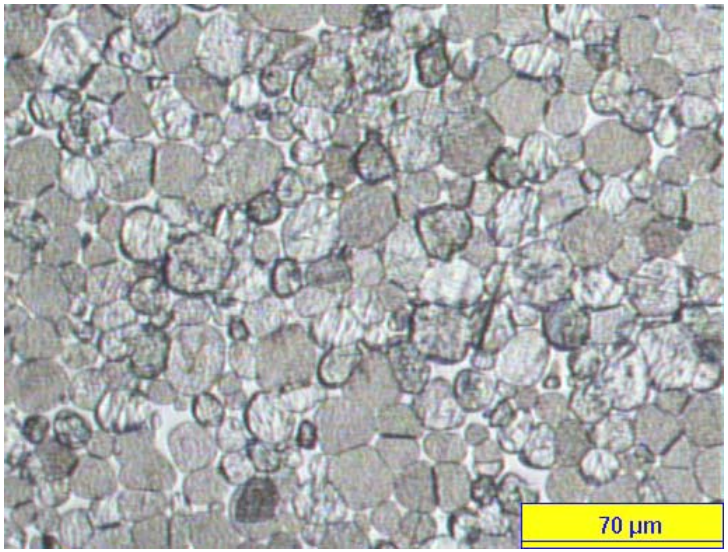


Flyweights

MIM of Tungsten Heavy Alloy



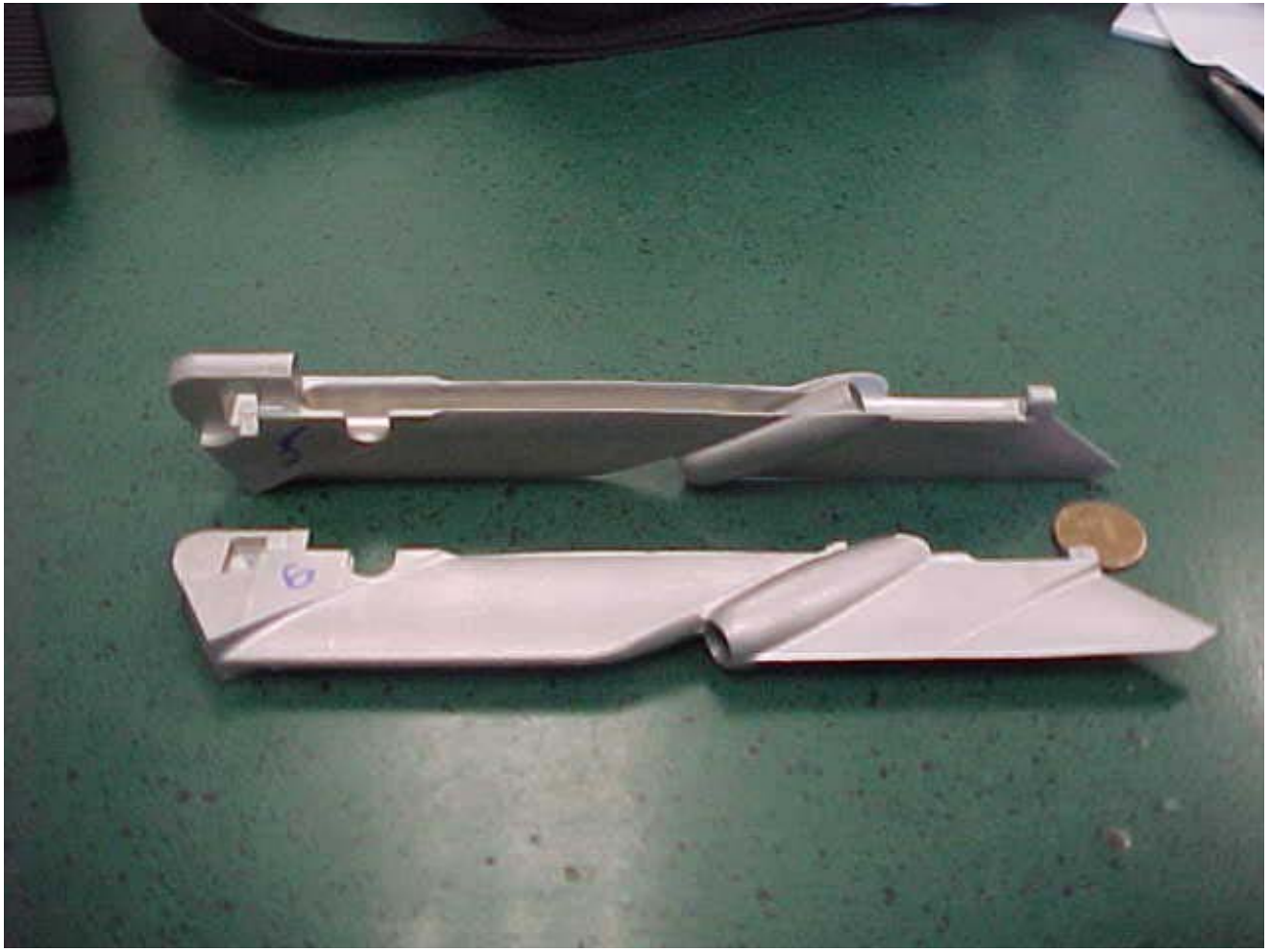
Baseline Press and Sinter



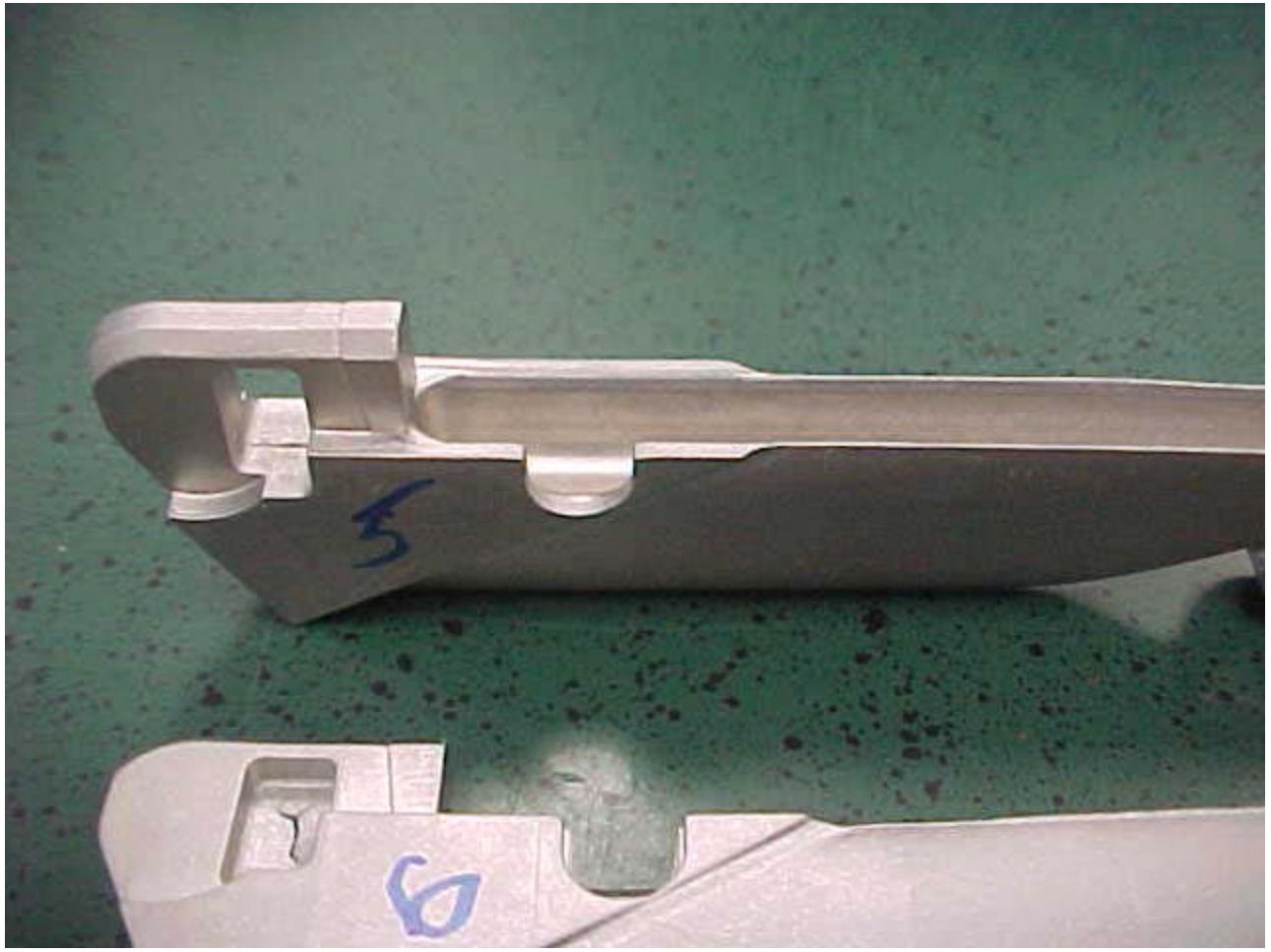
MIM Plate

PTI MIM has identical microstructure as traditional process

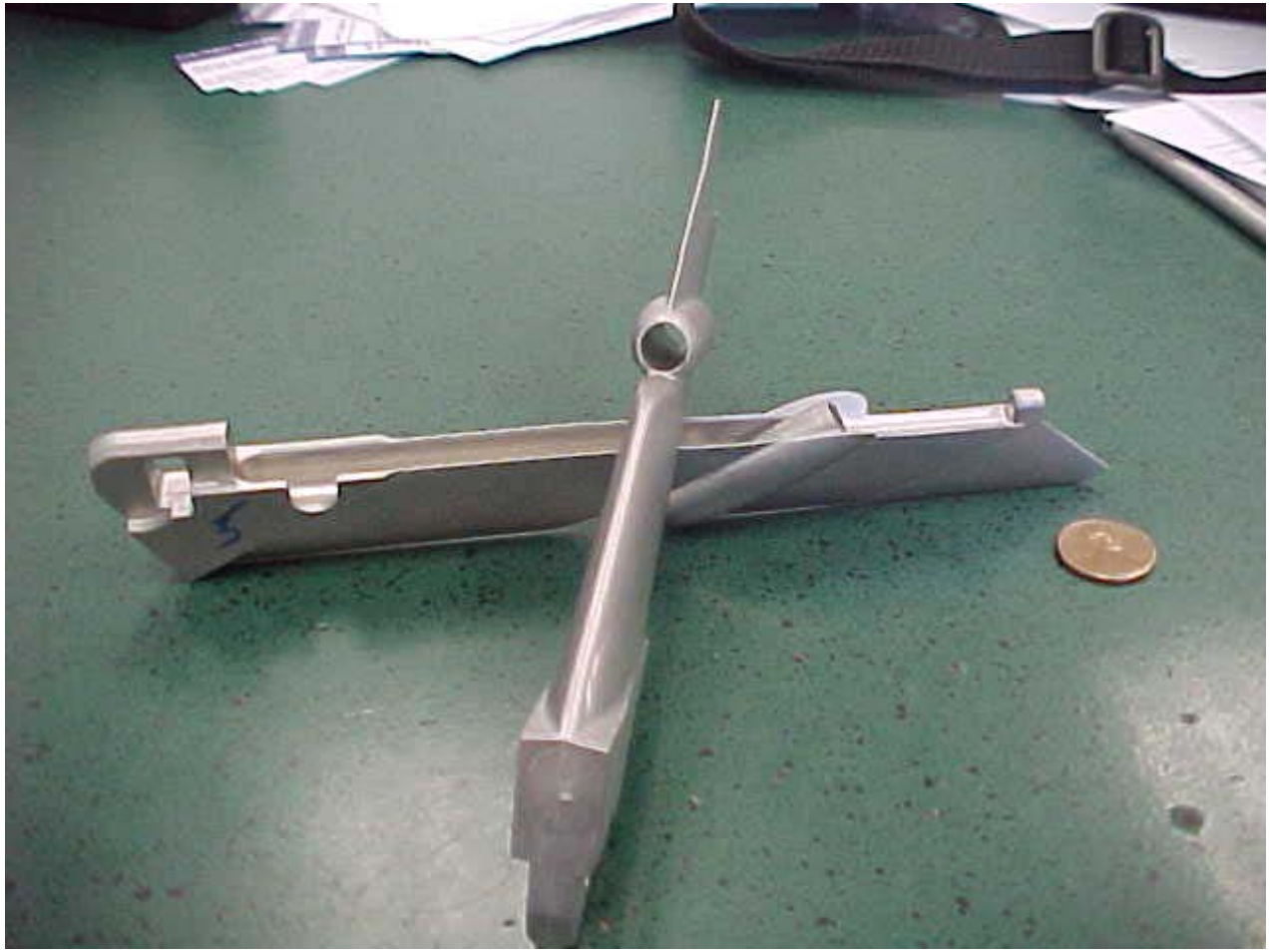
Complex Geometry and Co-Sintered Joints



As-Sintered 17-4PH MIM Wing

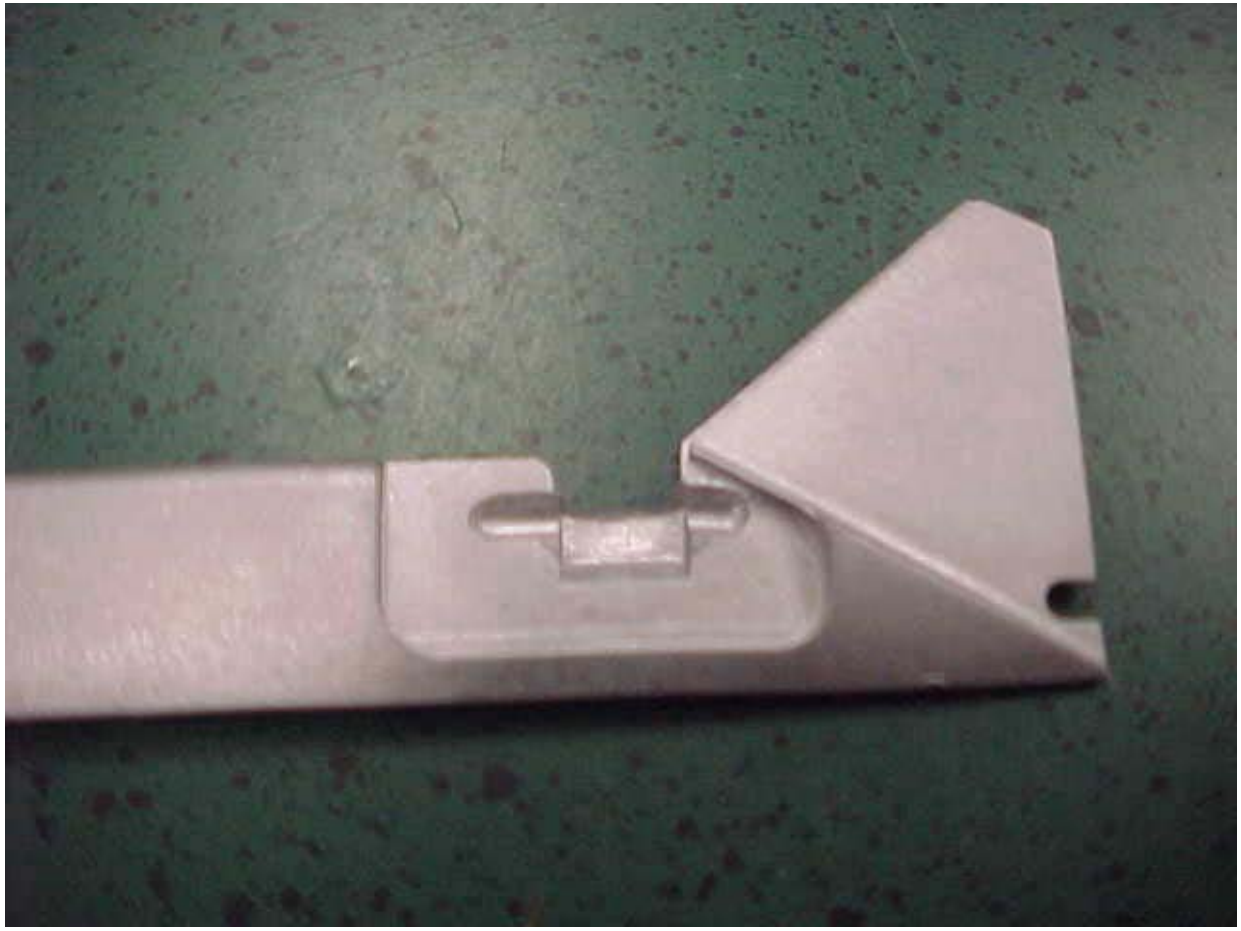


Closer view showing cavity on bottom



View through Nacelle

As-sintered 17-4PH Flaperon

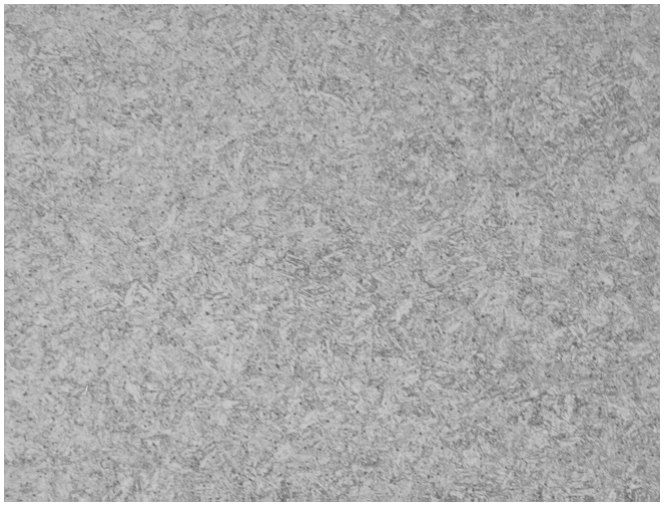


Closer view of back - As-sintered 17-4PH Flaperon

Phase I - Task I Component Review -cont

17-4PH MIM Microstructures

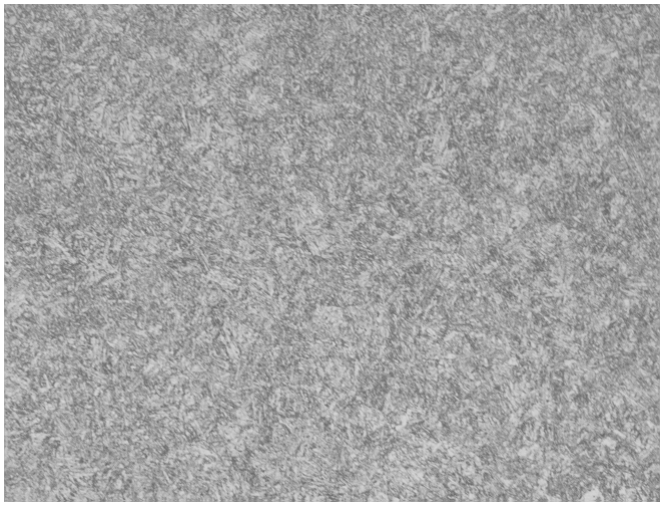
HIPed, standard H1025 H.T.



Edge of 5/8 inch dia bar

R_c =38

Cu=3.8



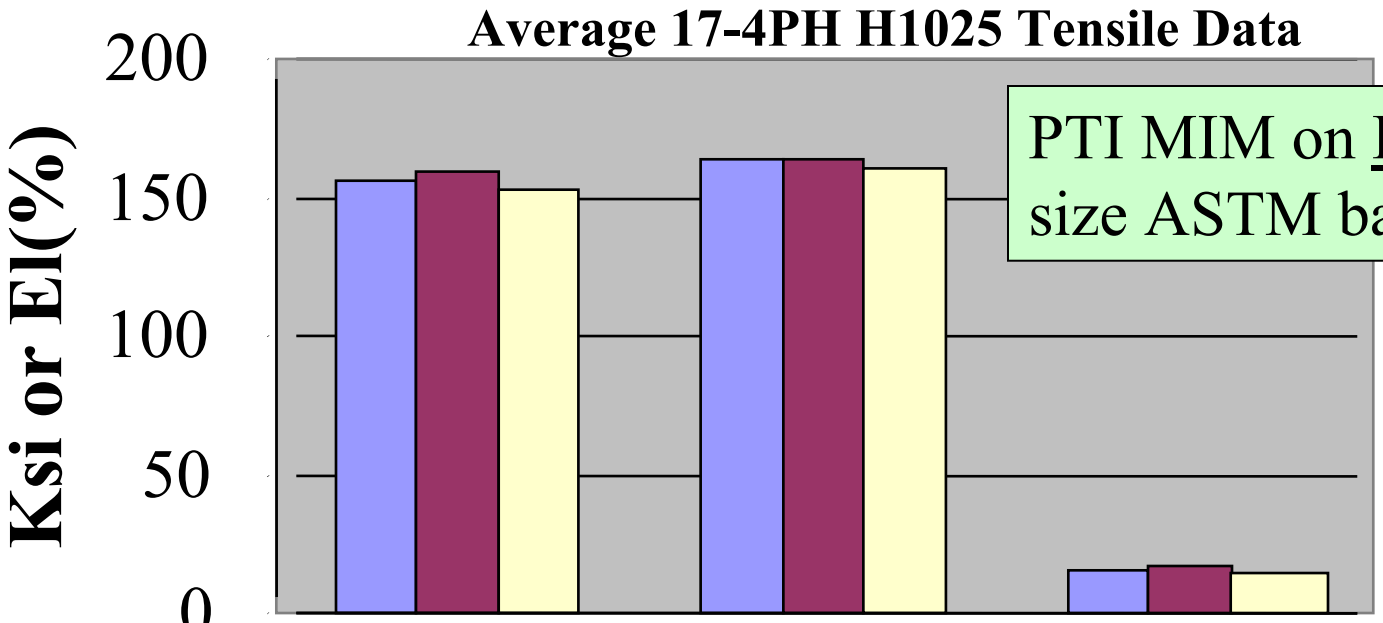
Center of 5/8 inch dia bar

R_c =38

Cu=3.8

Proper Control of Sintering Atmosphere Including Carbon Potential Allows for Uniform Properties in Thick Components

Phase I - Task I Component Review - cont



	YS(ksi)	UTS(ksi)	El(%)
MIM	153	165	12
Wrought	159	164	13
Cast	151	160	11

Notes:

unHIPed

C-0.03

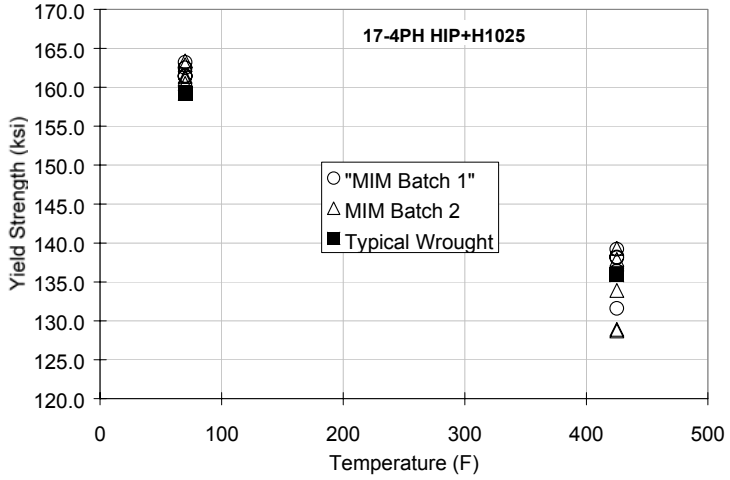
0xy-0.06

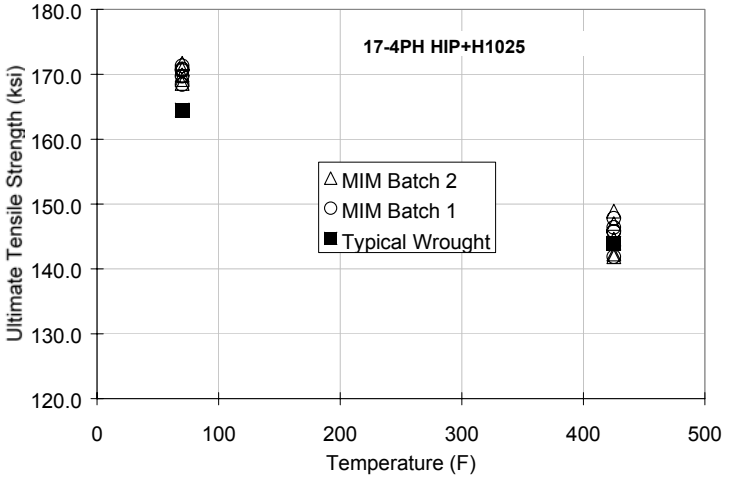
TD-99%

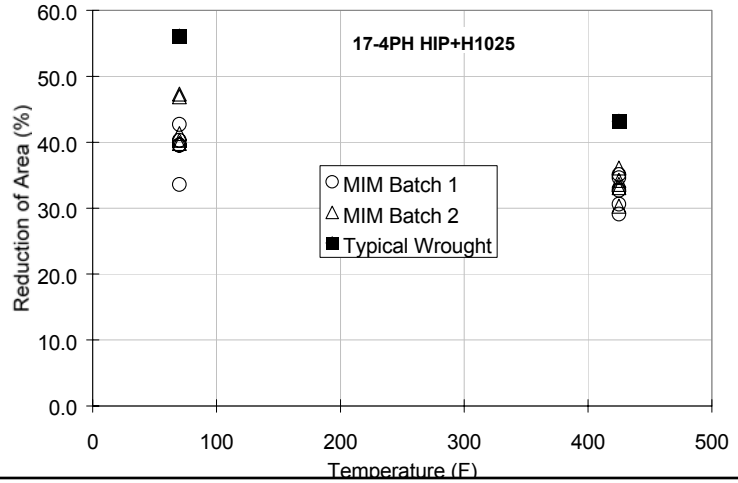
PTI MIM Tensiles are commensurate with Wrought specimens

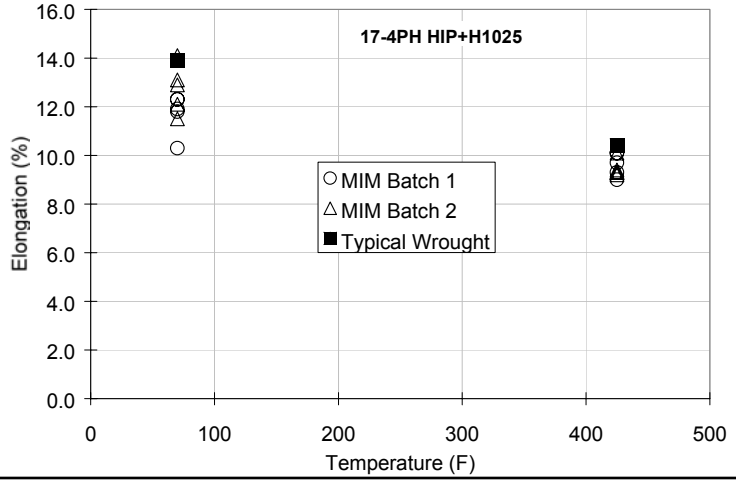
Tensile Comparison with Aerospace Wrought Data

HIPed H1025 17-4PH

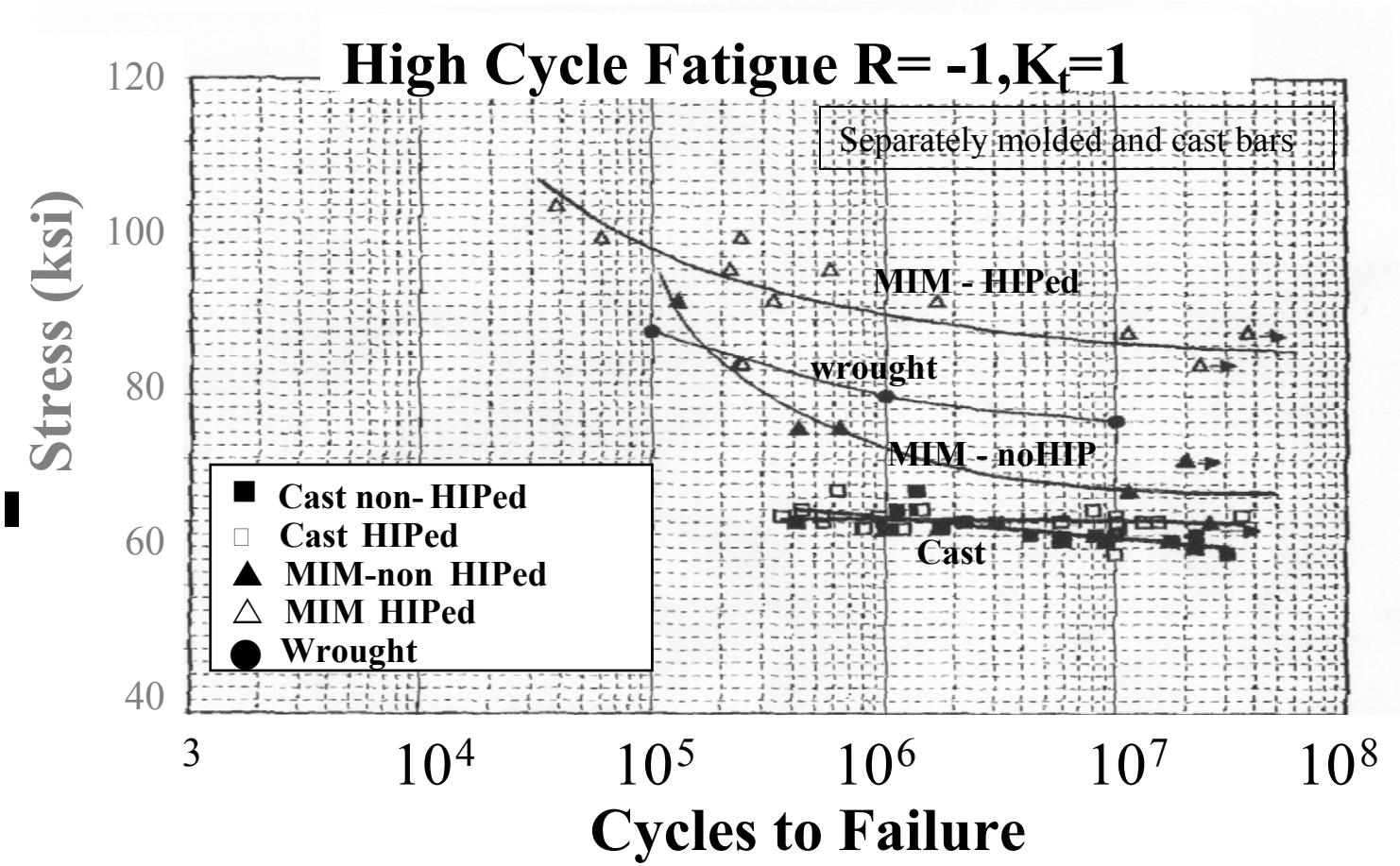








PowderFlo Tensile Data is Equivalent to Aerospace Wrought Processed Material



- MIM exceeds cast in all conditions
- MIM exceeds wrought in HIPed condition

MIM exceeds target goals of this program

Phase I - Task I Component Review – cont.

Typical Dimensional Tolerances

Feature	Best Possible	Typical
Angle	0.1°	2°
Density	0.2%	1%
Weight	0.1%	0.4%
Linear Dimension	0.05%	0.3%
Absolute Dimensions	0.04 mm	0.1 mm
Hole Diameter	0.04%	0.1%
Hole Location	0.1%	0.3%
Flatness	0.1%	0.2%
Parallelism	0.2%	0.3%
Roundness	0.3%	0.3%
Perpendicularity	0.1% or 0.1°	0.2% or 0.3°
Avg. Surface Roughness	0.4 μm	2 μm

Ref: R. German & R. Cornwall, The PIM Industry, Innovative Material Solutions, Inc., 1997.

Summary-Injection Molding at Polymer Technology

- Advantages of MIM
  - Cost Reduction-potentially 50% for the wing/flaperon
  - Component Flexibility
  - Ability to combine parts
  - Reduced Cycle Times, WIP
  - Ability to produce novel materials ability to reduce processing steps
- Advantages of MIM at PTI
  - Large components
  - Rapid Cycle time
  - Excellent properties in full scale components

40th Annual Armament Systems: Guns - Ammunition - Rockets – Missiles Conference

MEMS IMU – Common Guidance

Dr. Vicki C. LeFevre

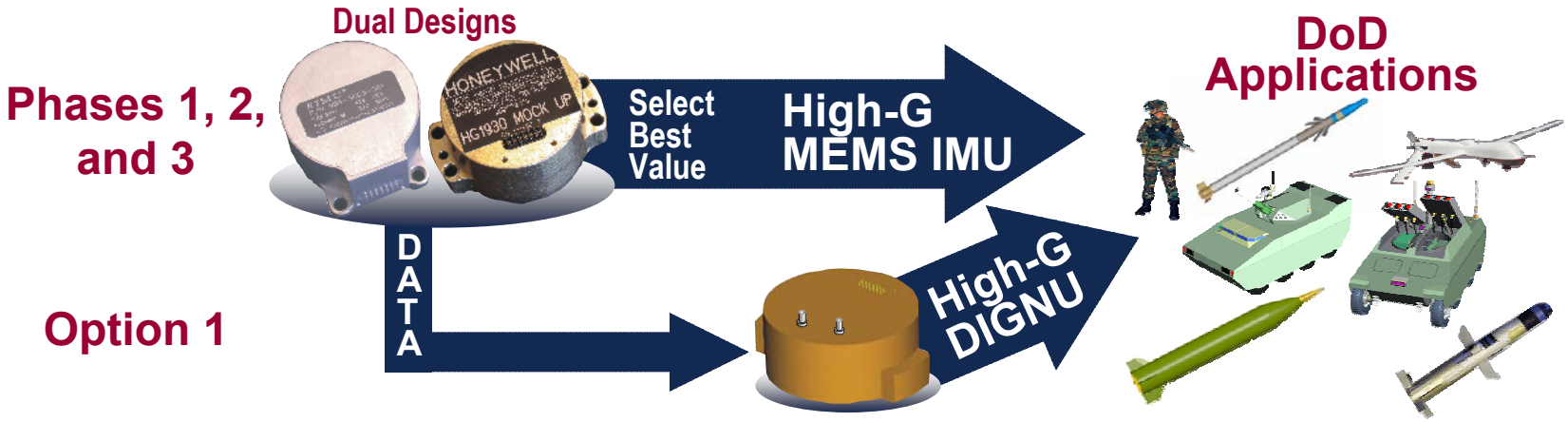
Mrs. Lynne K. Rider

Mr. David W. Panhorst

28 April 2005

Program/Business Strategy

- **Go To Multiple IMU Design / Manufacturing Teams**
  - L3/IEC
  - Honeywell/Draper/Rockwell Collins
- **Build to Common Requirement**
- **Leverage Process Improvements into Multiple DoD Applications**
- **Teams Incorporate Common IMU into Common, Deeply Integrated (GPS/IMU/AJ) Guidance & Navigation Unit (DI-GNU) Built to Common Specification**



Technology Investment Areas

S & T	***ManTech***
PERFORMANCE DRIVERS •Size •Weight •Performance •Power •Environment •Reliability	**COST DRIVERS** •Touch Time •New Capital Equipment •New Process Development •New Product Development •Low Volume Production
PERFORMANCE IMPROVERS •Technology Development - Design - Test - Evaluate •Improve Design •Improve Technology •Do It Again	**COST REDUCERS** •Automation - Improved Consistency - Reduce Touch Time •Upgrade Equipment -Better Control -Improved Yield •Consolidate •Economy of Scale

Using Manufacturing Technology to achieve Technical Performance Goals

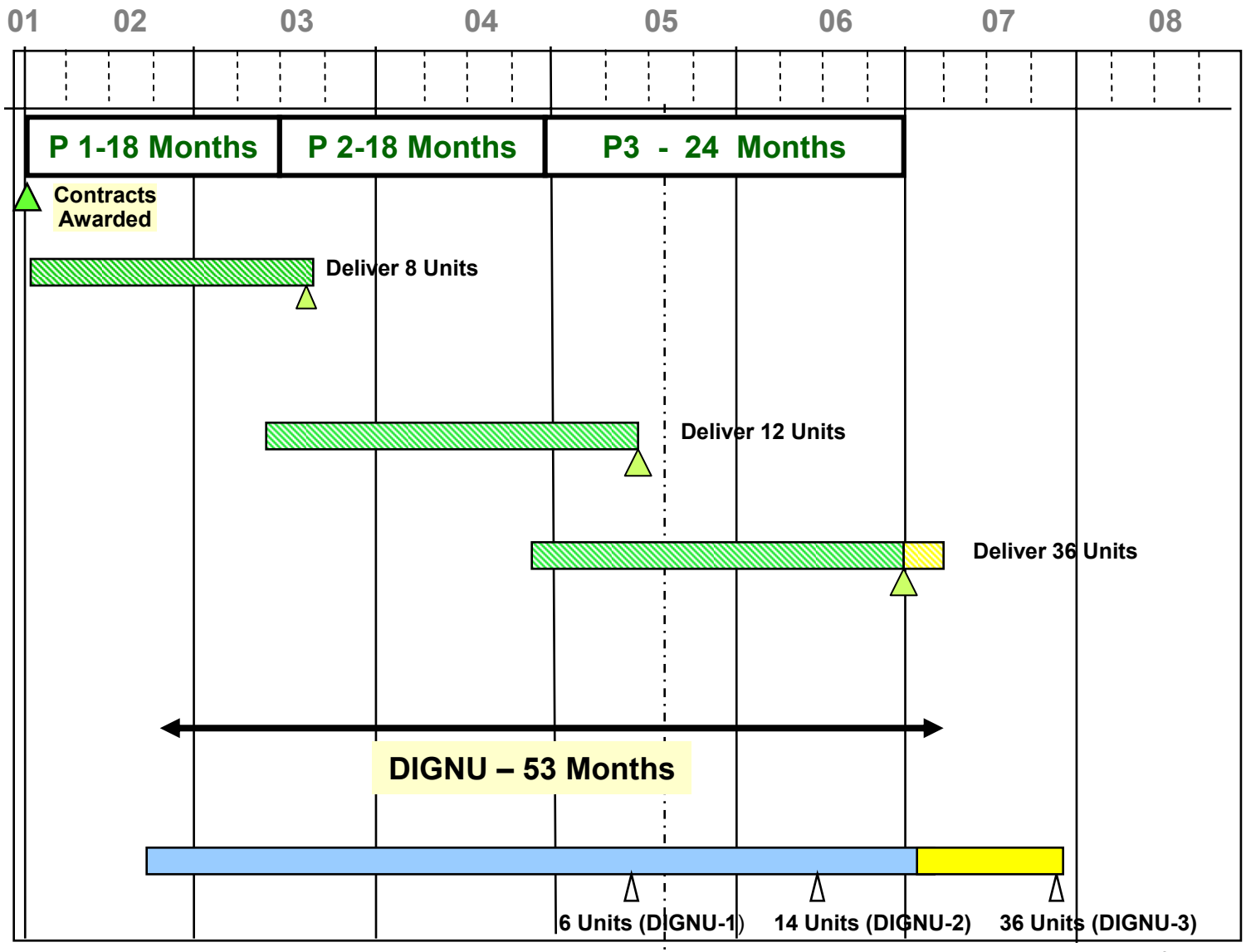
Program Milestones

Phase 1 (3 KTRs)
System Process/ Definition and Sensor and Electronic Design Development; JCG ICD IMU Demo 10K G, < 75 °/hr,< 9 mg, < 8 cu. in.

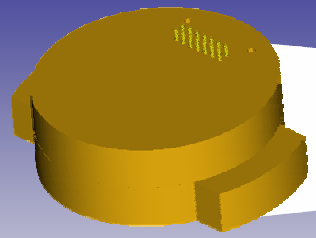
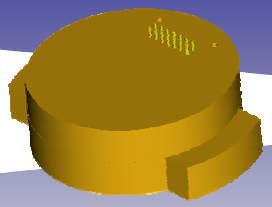
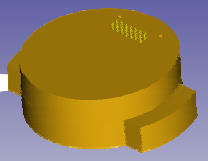
Phase 2 (2 KTRs Min)
IMU Demo > 20,000g, < 20°/hr, < 4mg, < 4 cu in over Environment,

Phase 3 (2 KTRs Min)
IMU Demo > 20K G, 1°/hr, < 1 mg
< 2 cu. in. over Environment,
< $1,200/IMU

Option 1 (2 KTRs Min) DI-GPS/ ISA-IMU / AJ, 4 cu. in., Intg Demo(s), > 20K G, < 1 °/hr over High-G Enviro < $1500



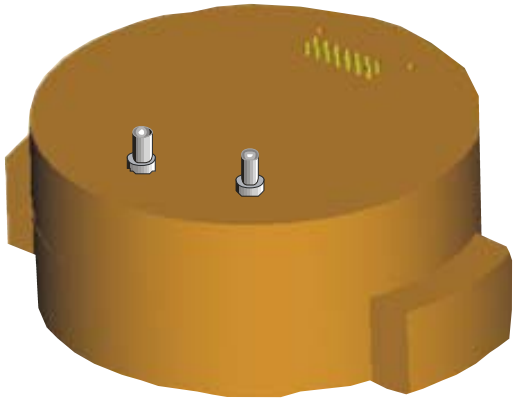
High-G MEMS IMU Evolution

Phase 1	Phase 2	Phase 3
		
<75 Deg/Hr <8 in3 >10 K Gs <9 mg	<20 Deg/Hr <4 in3 >20 K Gs <4 mg	<1 Deg/Hr <2 in3 >20 K Gs <1 mg
18 Months	18 Months	24 Months

Incrementally Shrink Volume and Power While Improving Performance

Deeply Integrated Guidance and Navigation Unit (DIGNU)

- Traditional GPS/INS Integration Enhances A/J Loss of Lock Capability
- Deep Integration Concept Provides 15-20 db A/J Over Conventional Tightly Coupled Solutions (SW Solution Only)



- Improves Weapon Effectiveness by Decreasing CEP
- Common Interface Control Document (ICD)
- Single Processor Architecture
- Higher Reliability

Knowing Where You Are
And Where You Need To Be

Program Output

Provide Common MEMS IMU/DIGNU for 90% of all DoD Applications

- ***Common Interface Control Document for compatibility across multitude of platforms***
- ***Common Performance Specification for consistent output signals***
- ***Two qualified suppliers producing interchangeable devices***

Implementation of System Engineering principles ensure that customer needs are met!

Quality Function Deployment (QFD)

- Two deployments to date
  1. focus on specific technical characteristics
     - provided valuable specification input
     - answered questions on interfaces, environments, and sensor performance
  2. focus on understanding the customer base and their top level requirements
     - resulted in a prioritized list of customers based on:
       - compatibility of production schedules
       - anticipated production volumes
     - allows evaluation of current requirements/cost drivers
     - provides basis for programmatic decisions

- Use of this SE tool resulted in comprehensive understanding of end-user needs

QFD – 1
Example of Results

Requirement	Original Spec	Range of Answers
Per unit cost	<$1200	$1650 to <$1900
Volume	<2 cubic in.	4 cubic in.
Dynamic G-range	30 g	70-100 g
Built in test	Coverage of 80% of testable failures	Max Power up BIT of 95%
Max input power	≤5W	5.25W

Customer QFD Results (by Phase)

Customer	Prod.Yr	IMU vol	Performance
MRM	2009	Phase 2	Phase 2
ERM	2006	Phase 2	Phase 2
PGMM	2008	Phase 2	Phase 2
Excalibur	2005	Phase 2	Phase 2
AGS-LRLAP	2008	Phase 2	Phase 2
SDB	2008	Phase 2	Phase 3
APKWS	2006	Phase 2	Phase 3
JCM	2008	Phase 2	Phase 3
GMLRS	2005	Phase 2	Phase 3
JSOW	2009	Phase 2	Phase 3
JDAM	2008	Phase 2	Phase 3
THAAD	2007	Phase 2	Phase 3
WCMD	2007	Phase 2	Phase 3
Soldier Navigation	2006	Phase 3	Phase 3

Next Steps

- End User feedback on ICD and Performance Specification
  - Contact Information to receive a copy of documents

    Tobey Coombe
    John J. McMullen Associates Inc.
    Engineer
    (202)-741-2041
    TCoombe@JJMA.com
- Requirements data being tracked with SLATE software
- ICD and specs in Configuration Management Control

Summary

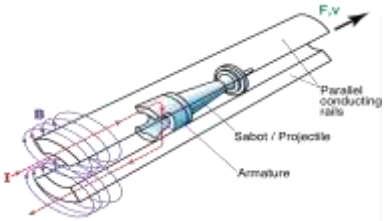
- Program structured to meet 90% of end user needs
- Progressing toward meeting both technical and programmatic Phase 3 goals by 1QFY07
- System Engineering has added discipline to the approach

40th Annual Armament Systems:
Guns, Ammo, Rockets, Missiles
April 25-28, New Orleans, LA

Development and Testing of High Explosive (HE) Projectiles for Electro-Magnetic Gun Army Tech Objective (ATO)

Manfredi Luciano
RDECOM-ARDEC
Picatinny, NJ

Army Program
First EM Technology Spiral



FY04	FY05	FY06	FY07	FY08	FY09	FY10	FY11	FY12	FY13

STO | **ATD**

- **S** — Special ASARC
- **1** — Full Scale Lethality vs Complex Targets Risk Reduced
- **IPR** — POM 08
- **2** — Launcher Life Risk Reduced
- **3** — Energy Density Risk Reduced
- **A**
- **4** — Subsystem Thermal Management Risk Reduced
- **5** — System Integration Risk Reduced

6.2 designs

Proposed Subsystem Designs

Subsystem Models

Full caliber tests

2-5MJ, 5000 kg, uncooled, unruggedized rectangular bore (60mm equiv) fully cantilevered

unguided multipurpose & unguided KE rounds. unguided KE, terminal ballistics vs. Tank @ 8MJ ME level

Full firing chain @ 2-5MJ. Single Shot Externally supplied prime power

Burst firing chain. Integrated prime power. Lethality vs. BMPs, bunkers, buildings, personnel

2-5MJ, 5000 kg, cooled, ruggedized

2-5MJ muzzle energy LOS EM Gun system

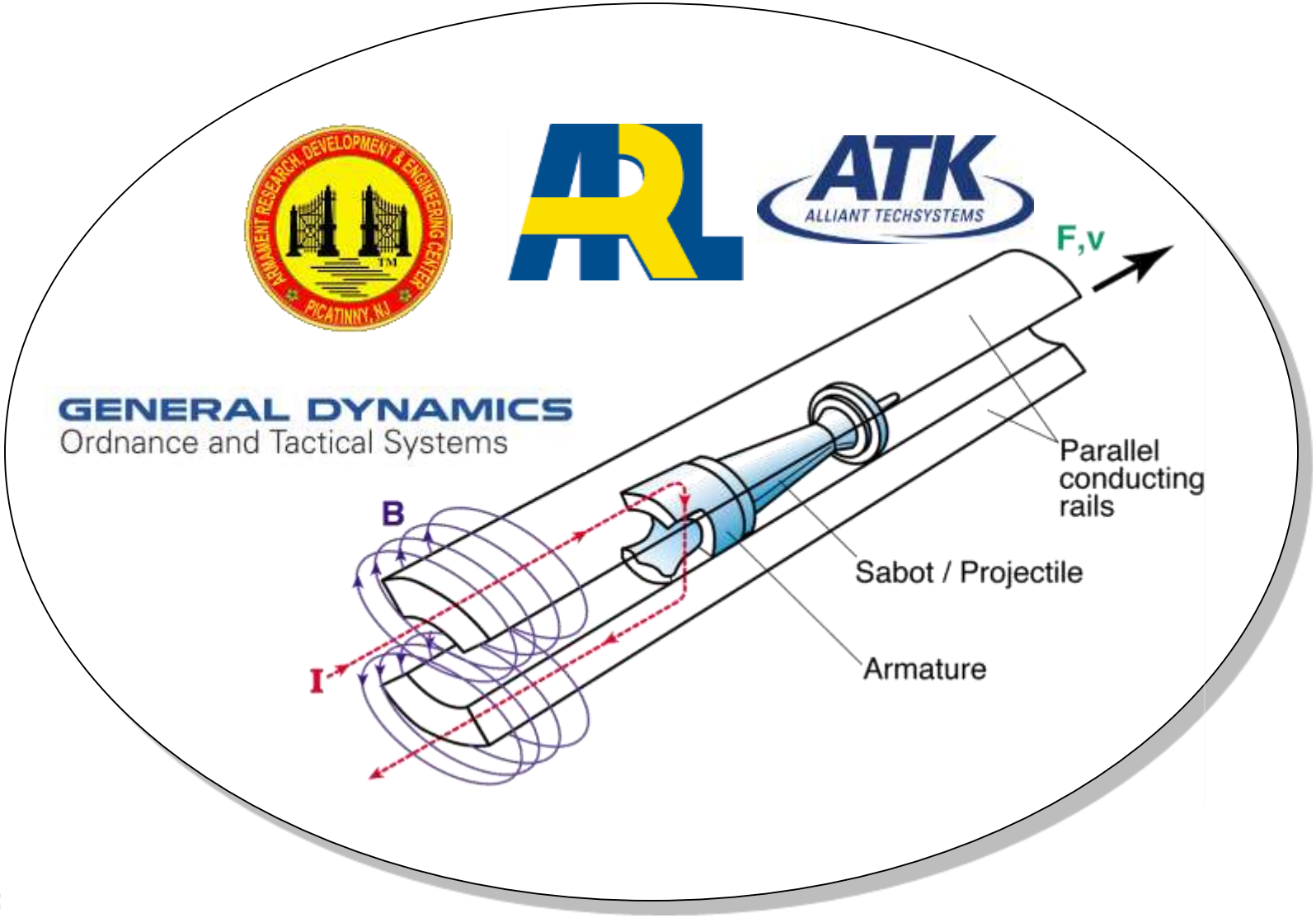
< 19 ton platform fires burst,

Perforates BMP @ 2km

Multi-burst operation

Special ASARC approved this ATD approach

Intra Army, Multi-Contractor Collaborative Team



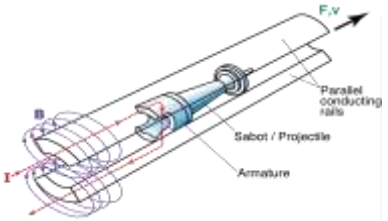
Authors:

ARDEC: Manfredi Luciano, David Okken, Vinod Nagori, Justin Rhodes, Robert Bryan, John Grau

ARL: Alex Zielinski

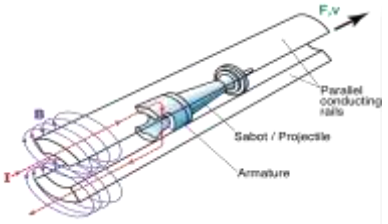
GD-OTS: Karl R. Linde and ATK: Eric Quist

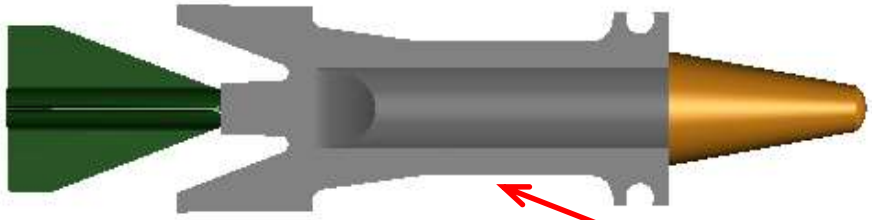
H.E. Integrated Launch Package (ILP) Feasibility Task



- **Objective:** Demonstrate HE ILP from EM Gun, Achieving TRL-5.
  - Integrate armature, flight body, fuze, & HE for a 2 km target demo
- **Approach**
  - Test from ARL ½ MJ Electro-Magnetic Gun
  - Task order contracts to GD-OTS & ATK for Hardware Mfg
  - Team intellectual collaborative effort
    - Maturing general EM technology
    - No competition between parties; non-tactical bullet
- **Concerns**
  - Can high explosive & fuze survive high current, high magnetic field environment?
  - Can large body, fin stabilized sub-projectiles be launched from high lateral load and high voltage environment?

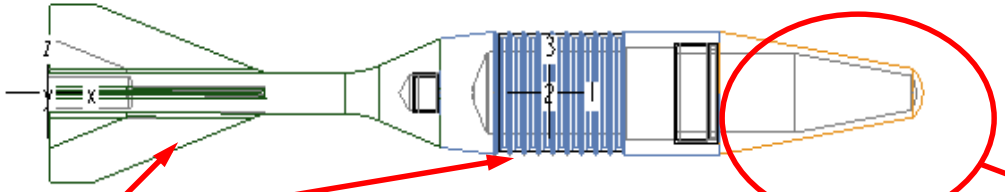
HE ILP Initial Design





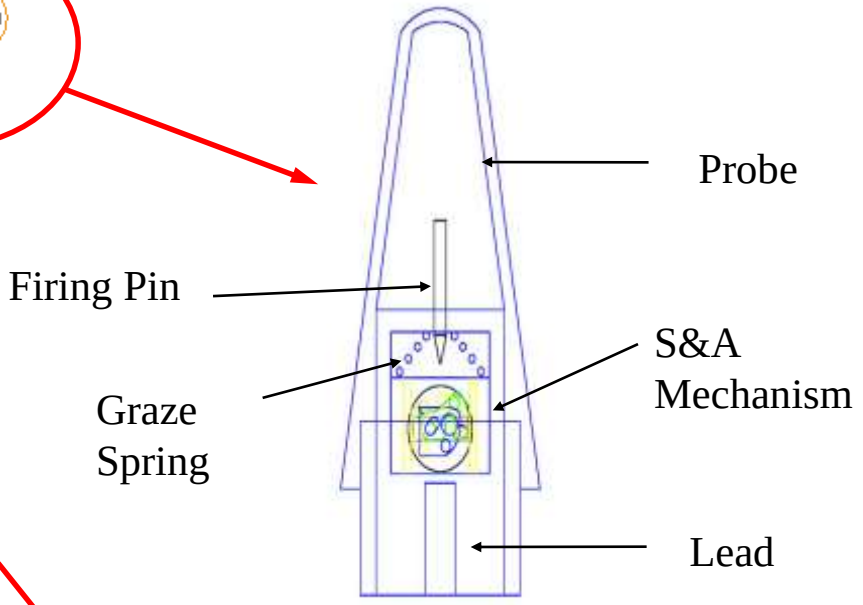
Integrated Launch Package:
Integrates Sup-Projectile, Sabot, & Armature

Armature for EM Launch



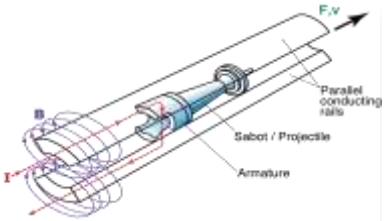
Body & H.E. Based on M792 (25mm HEI-T)

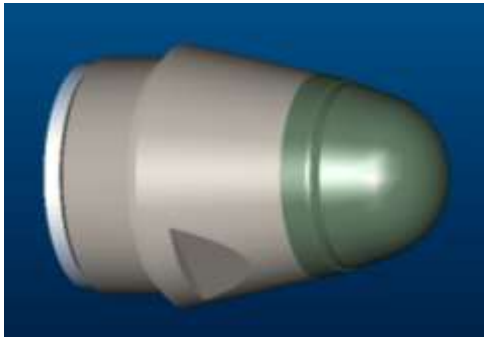
No Spin Environment
- **-Requires Boom/Fin for Stability**
- **- Clipped Delta, Four Bladed**
- **-Requires 2nd Fuze Arming Mechanism**

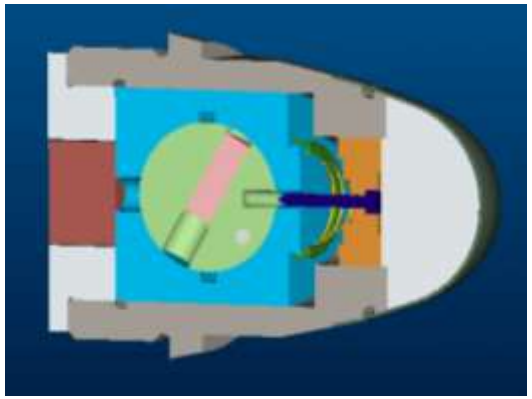


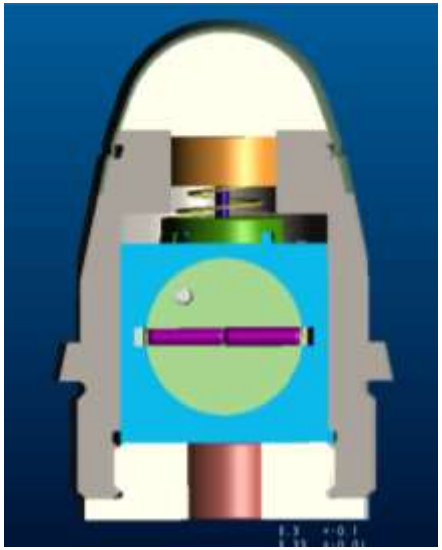
Dual Arm Fuze: Setback & EM

EM ILP Fuze Concept









Dual Arm:

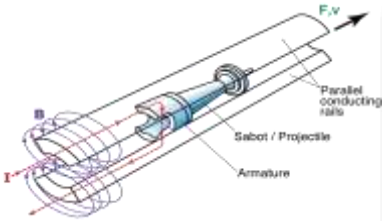
Setback Stab Plunger

Magnets Polarized from EM Field

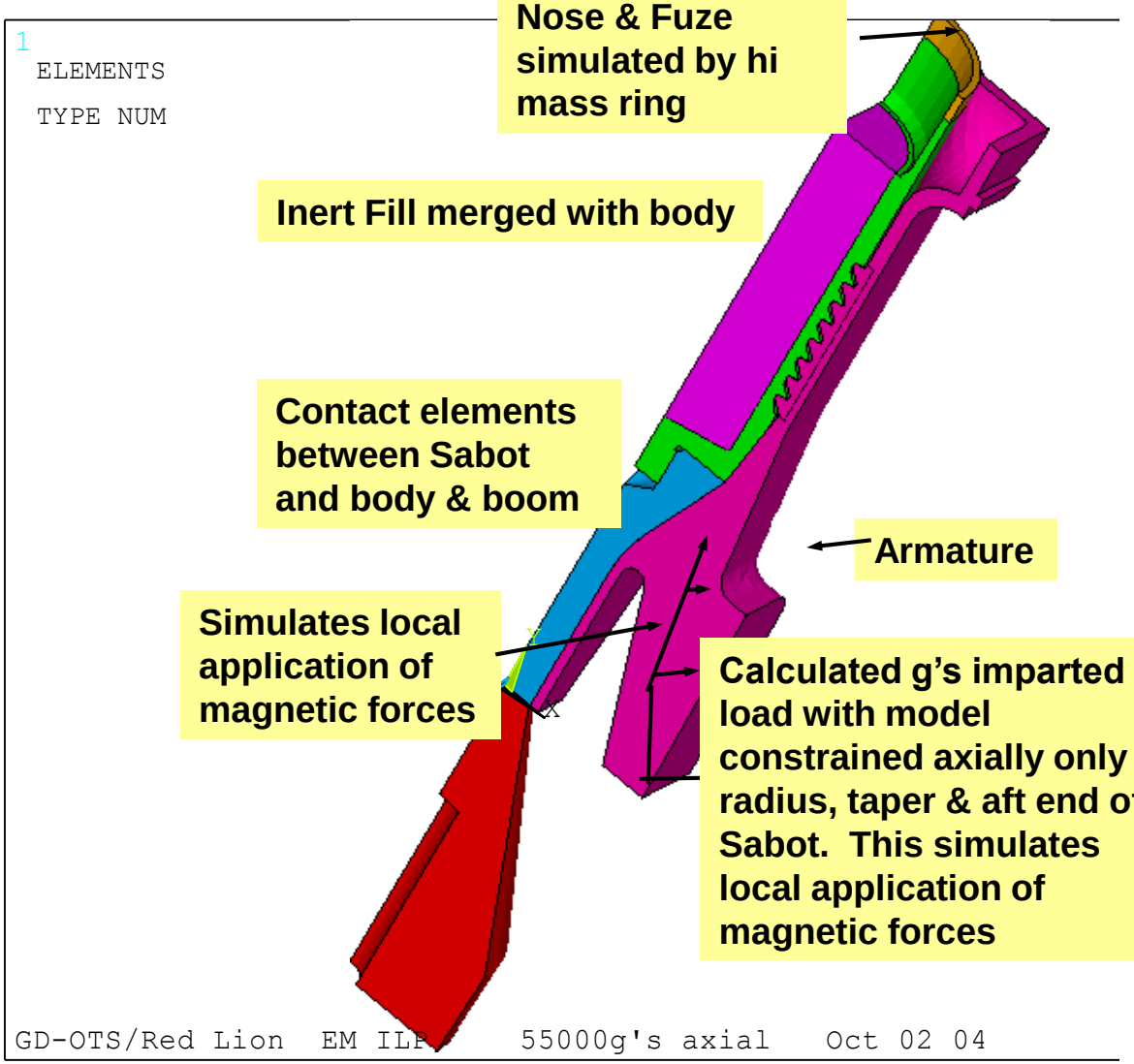
For More Info, see 49th Annual NDIA Fuze Conference Paper

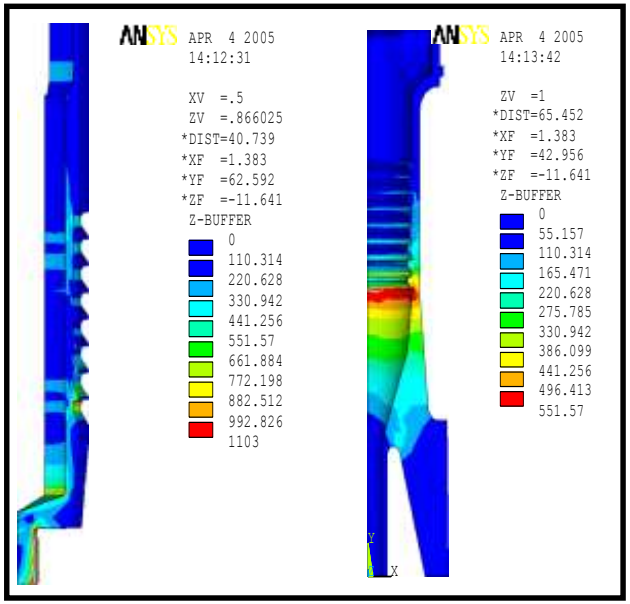
April 5 – 7, Seattle, WA

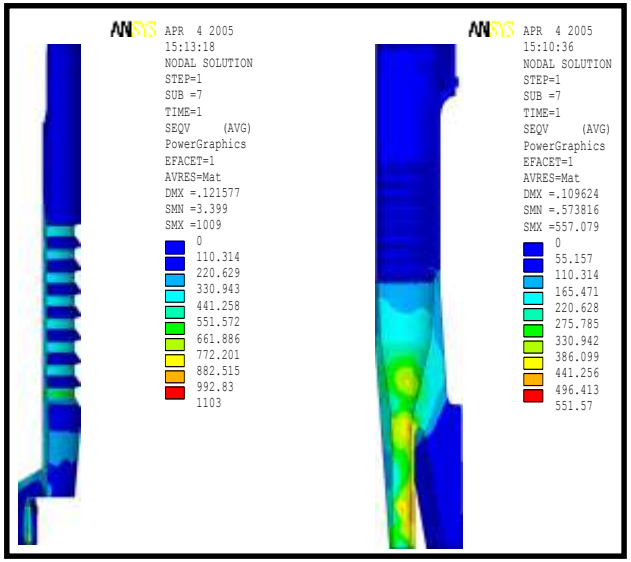
Modeling & Simulation - FEA



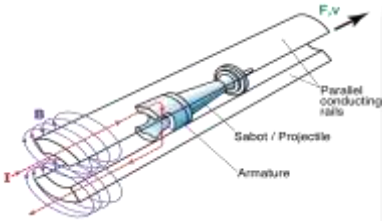
FEA Model







ILP Design & Assembly



Fin/Boom
Mtl: Al 7075
Mass: .020 kg

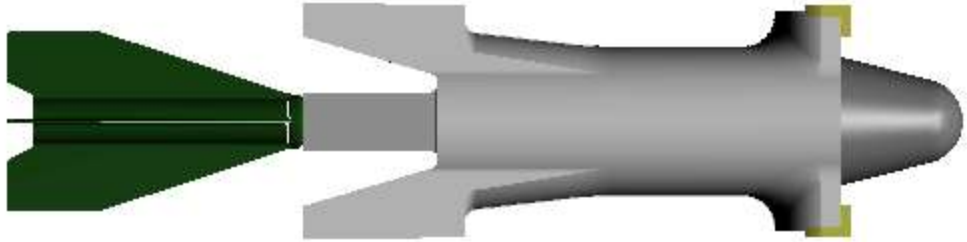
Body
Mtl: 4140 Steel
Mass: .084 kg
Inert H.E. Fill .026 kg

Dummy Nose
Mtl: Al 7075
Mass: .027 kg

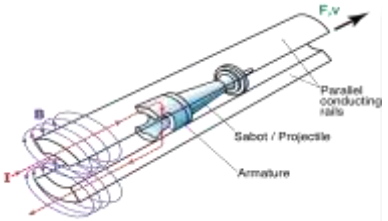
Bore Rider
Mtl: Nylon 42A
Mass: .001 kg

Sabot/Armature
Mtl: Al 7075
Mass: .106 kg

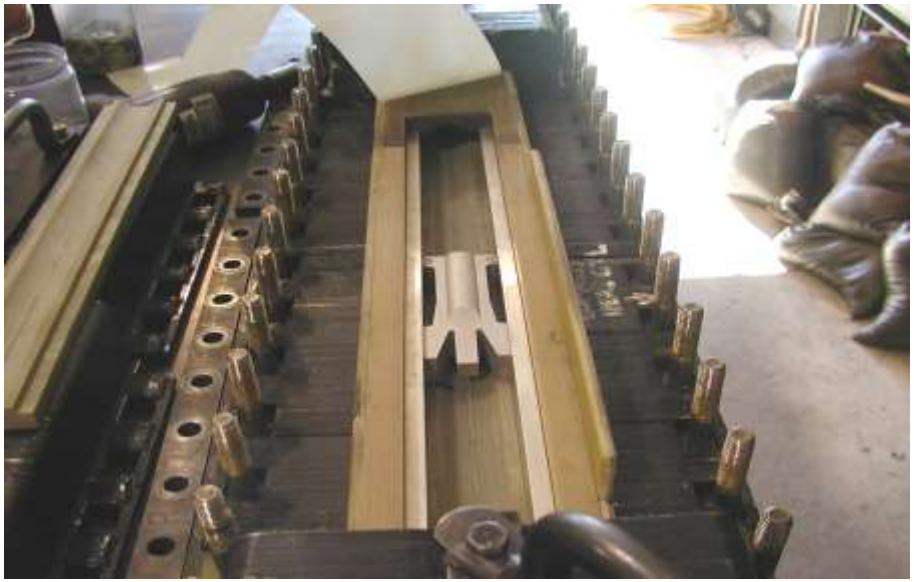
Actual Hardware



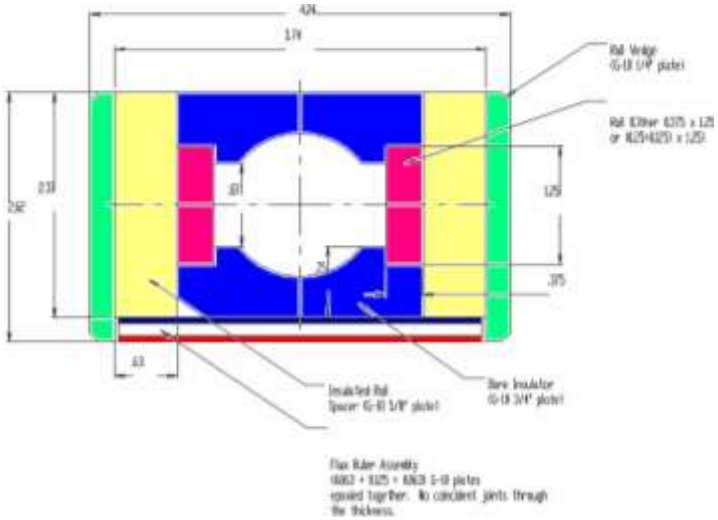
Test Vehicle - ARL ½ MJ EM-GUN



- Max Muzzle Energy = ½ MJ
- Peak Current = 1MA
- Gun Length = 2.8 m
- Gun Cross Section = 22mm x 44 mm
- Scalloped Insulation Cross Section area = 38 mm (diameter)
- Rails replaced after each shot.

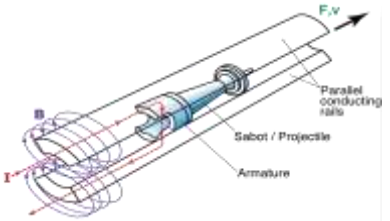


Test Launcher w/ Slug



Muzzle View

Test Results - Slug Test

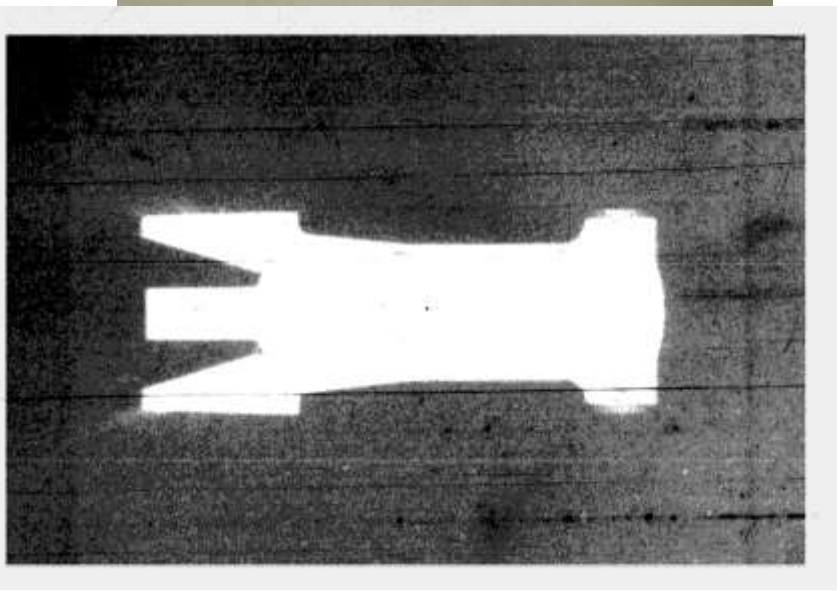


Objectives:

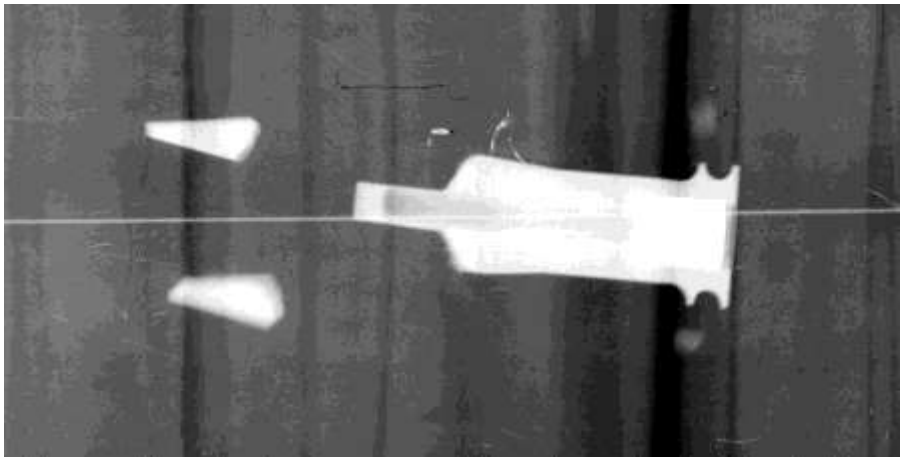
- **Verify Acceleration & Velocity**
- **Assess armature for current flow**

Ballistic Goals:

- **1200 m/s Muzzle Velocity**
- **276 gms Mass**

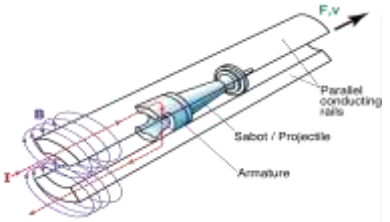


Shot One, Low Current



Shot Two, Higher Current

Test Results - ILP



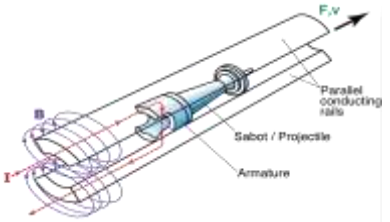
- Six Projectiles tested
  - SOD test
  - Two fin orientations, 90 and 45 degrees
- Two out of six were successful
- Fin blades and hub failed seen
- Results seem to be a function of; Acceleration, Transition Current, and Muzzle Current.

Fin Orientations

90º

45º

SOD Test X-Rays



X-Ray Picture 22” From Muzzle

Shot # 1

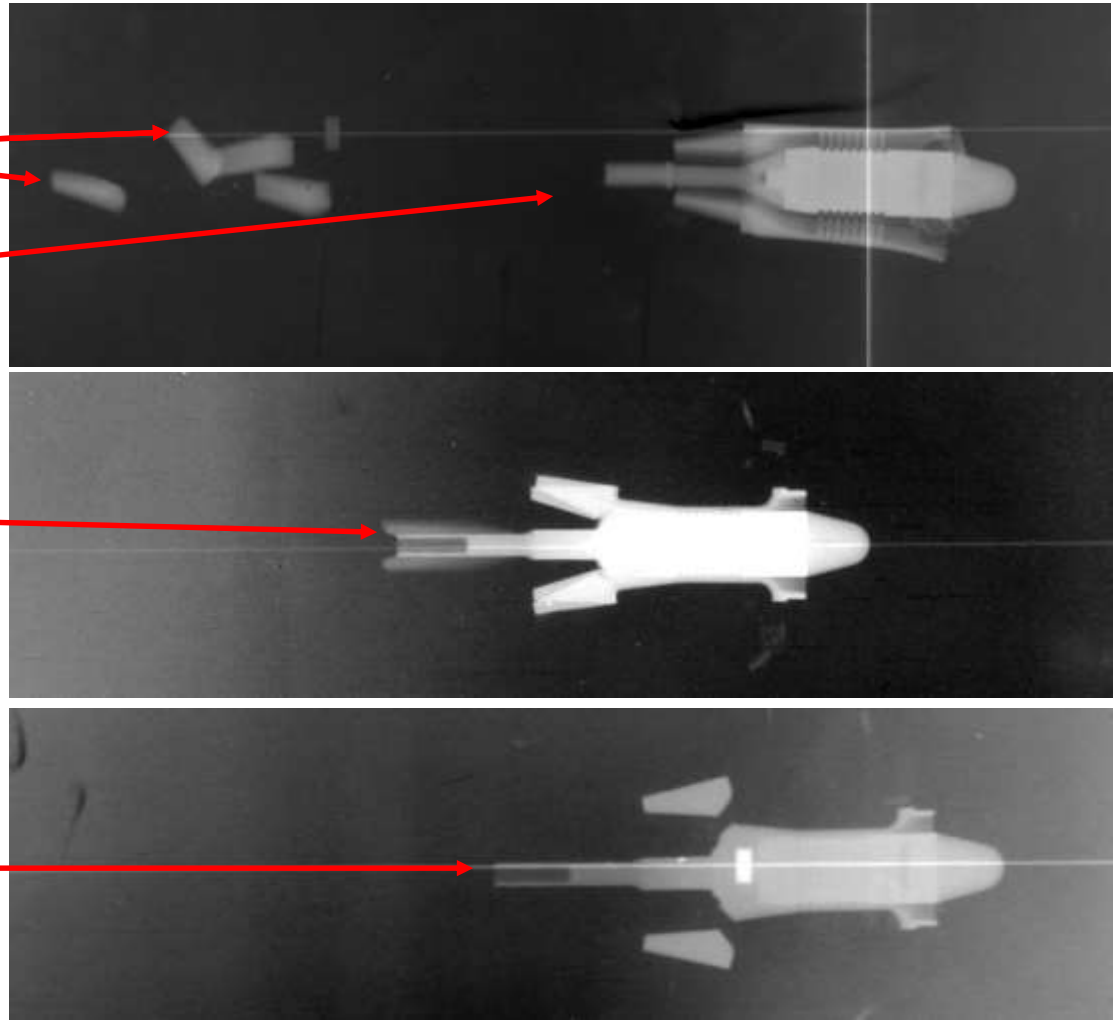
- **Armature Legs Fractured On Muzzle Exit**
- **Fin Blades & Hub fractured**

Shot # 3

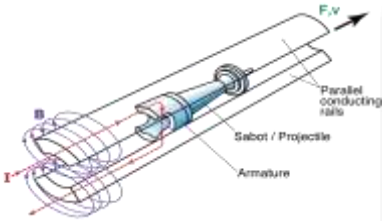
- **Fins & Fin-Hub Intact**

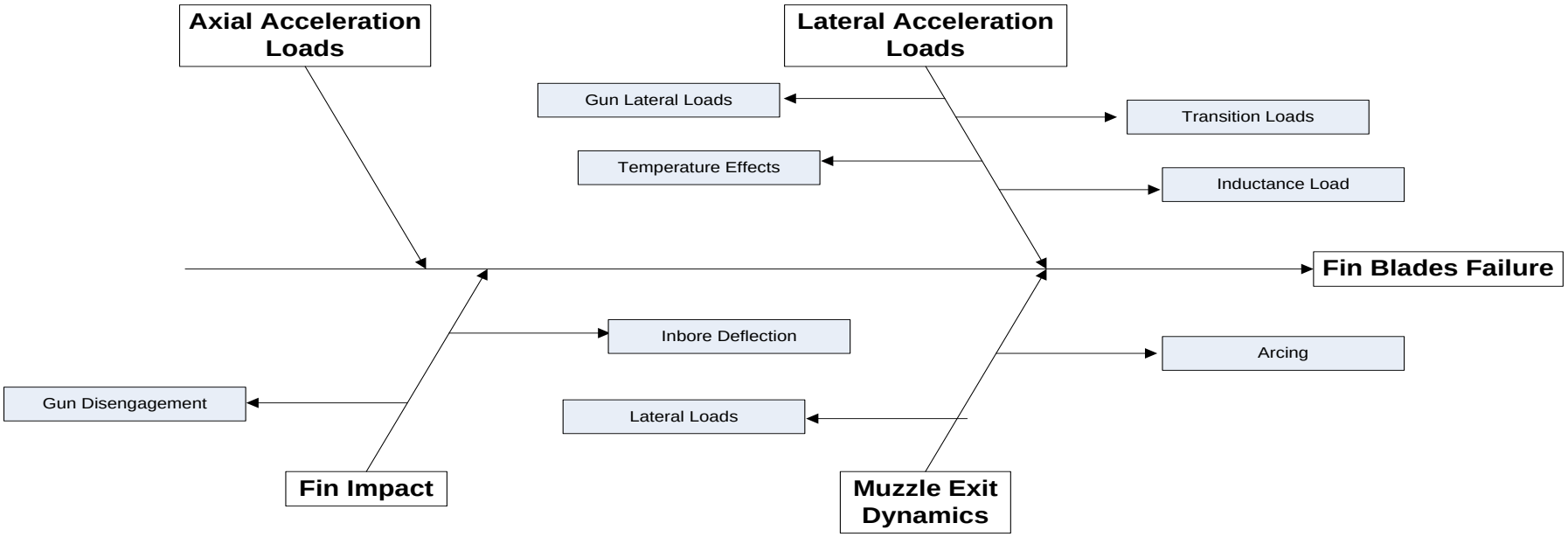
Shot #6

- **Fins Missing**
- **Fin-Hub Intact**



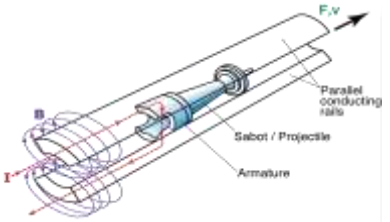
Failure Analysis





Root Cause Fishbone

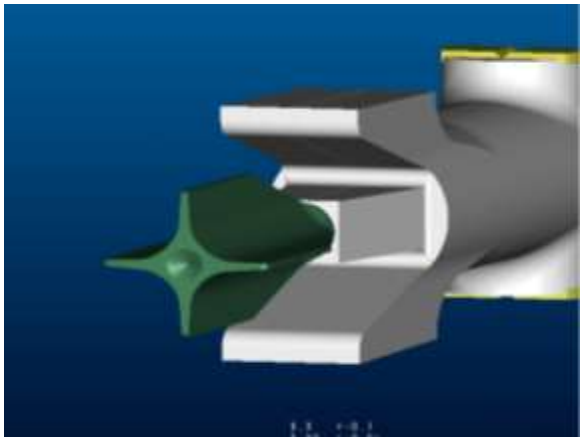
Go- Forward Plan



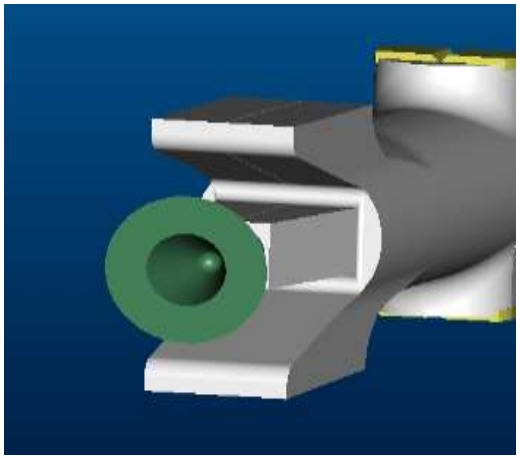
Next Test Series - May 2005

- To Minimize Muzzle Exit Effects:
  - Add muzzle shunt to gun
- To Minimize Transition Loads:
  - Increase armature length for increase rail surface contact
  - Increase Chevron thickness
- Two New Fin/Boom Designs, two materials each:
  A. Mod A – Increase Strength Four-Bladed Fin
  B. Mod B – Flare

Note: Fin designs are modular for quick changing at test.

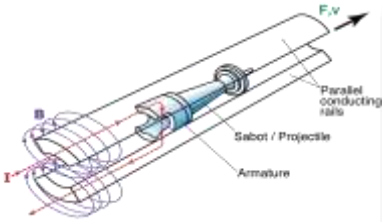


Mod A – Four-Bladed Fin



Mod B – Flare

Summary



- **Designed correctly for axial loads.**
  - **Design survived 62.8 KG's.**
- **Assumed & Designed for lateral loads at 20% of axial (11 KG's).**
- **Do we understand all lateral loads?**
- **Do we understand muzzle exit dynamics?**

XM395 Precision Guided Mortar Munition (120mm PGMM)

Responsive, Standoff Precision Lethality for Highly Deployable and Mobile Forces

"Translating Lessons Learned into Systems Requirements"
40th Annual Armament Systems: Guns-Ammunition-Rockets-Missiles Conference & Exhibition
April 25-28 , 2005

Presented By: James Terhune and Anthony Pezzano
OPEO Ammunition/OPM CAS/ OPM Mortars

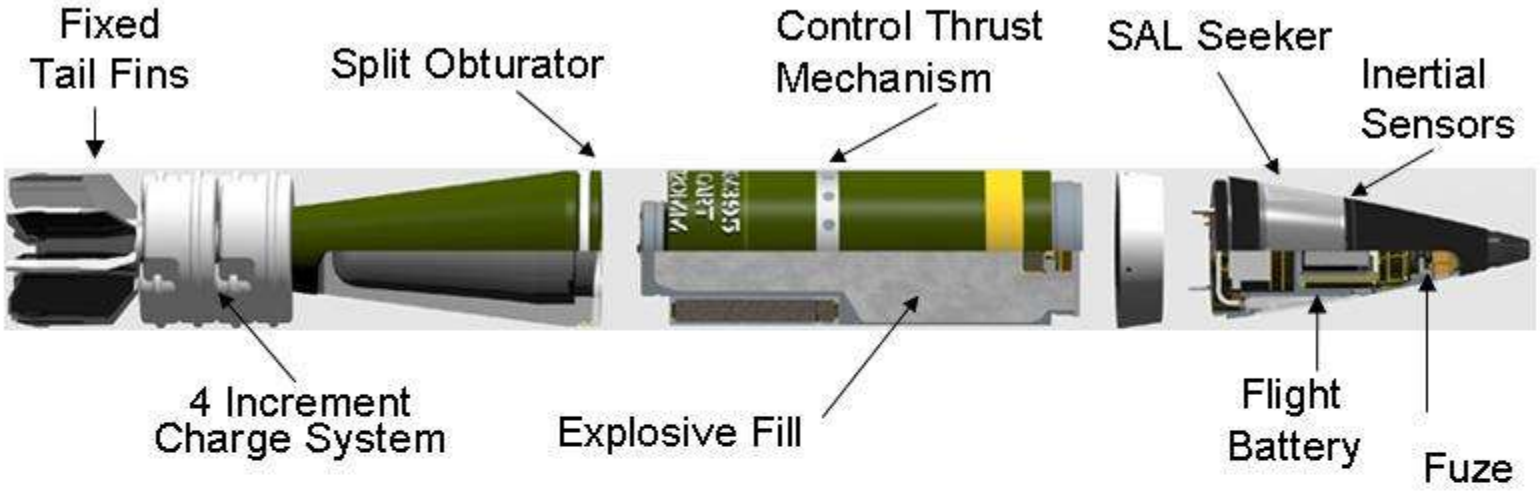
Task

Present a Summary of the Product Manager's Approach to PGMM Training

Purpose

Develop Systems Approach for PGMM Training Concept Utilizing Six Sigma Principles and Processes

PGMM Description



System Requirements (Key Performance Parameters):

Increment I

Lethality: Incapacitate protected personnel, in two rounds or less, within:

- Earth and timber bunkers
- Brick over block masonry structures
- Stationary lightly armored vehicles

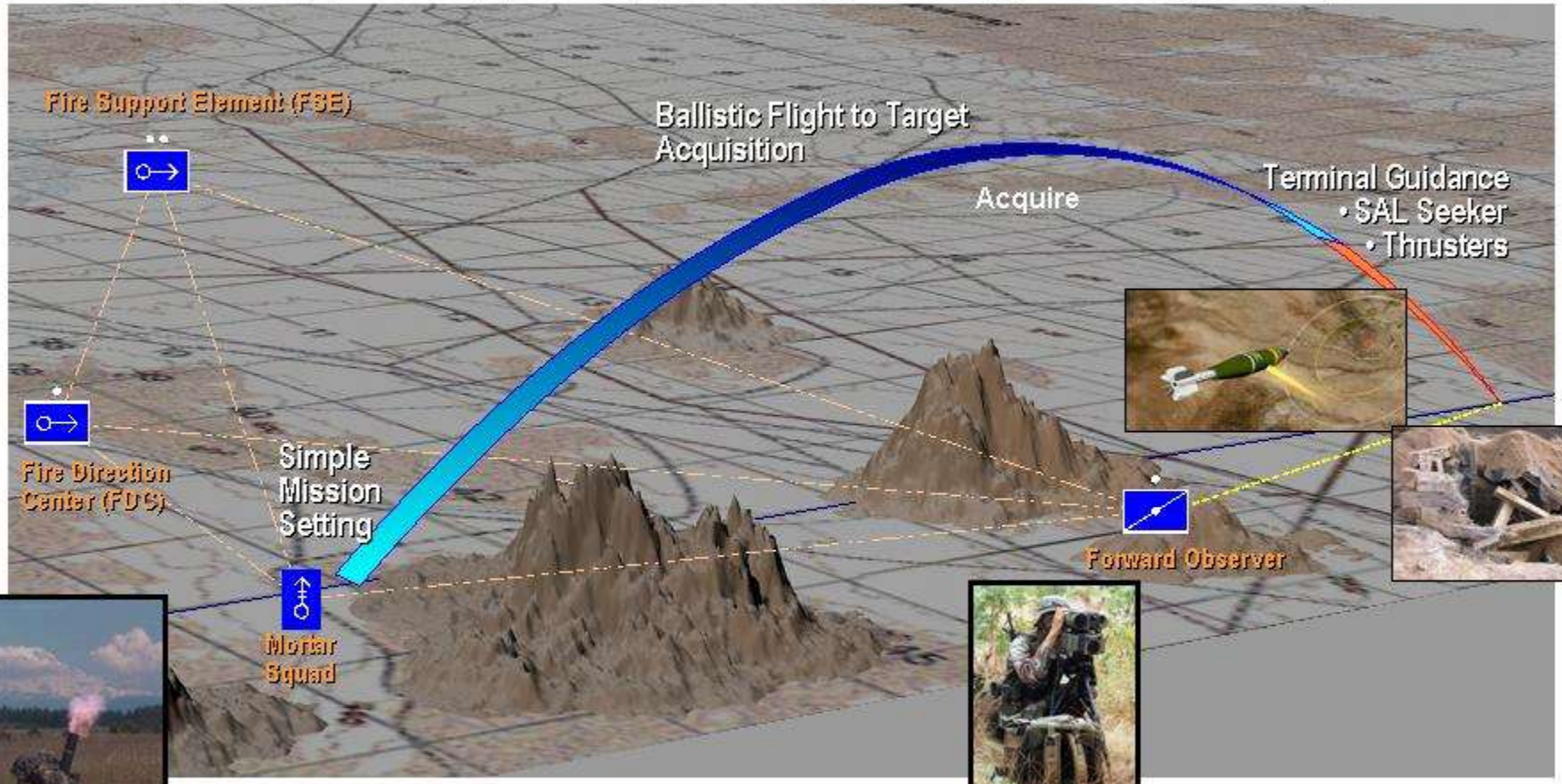
Maximum Range:

- Current Force: 7.2km (Threshold), 10km (Objective)
- Future Combat System (FCS) Mortar: 8km (T), 10km (O)

Compatibility:

- 120mm Battalion Mortar System
- Stryker - Mortar Carrier
- FCS Non-Line of Sight (NLOS) Mortar
- Current / Future Laser Designators & Fire Control Systems

PGMM Operations



Leverages Existing Fire Support Systems
Reduces Collateral Damage

Masonry Structures
Earth and Timber Bunkers
Light Armor Vehicles

Precision Munitions Increase Warfighter Effectiveness

Mortar Infrastructure In Place

Joint Service Forward Observers & Designators

Mortar Fire Control System

- 120mm Mortars in current infrastructure
  - 120mm Mortar Platforms: M121 (carrier-mounted), M120 (towed), Stryker - Mortar Carrier
  - 120mm Mortar Munitions: HE, Smoke, Illumination (Visible & Infrared)
- Light-weight Laser Designator Range Finder (LLDR)
- Fire Control / Command & Control Links
  - Mortar Fire Control System (MFCS)
  - Advanced Field Artillery Tactical Data System (AFATDS)

Towed 120mm (Ground Mounted)

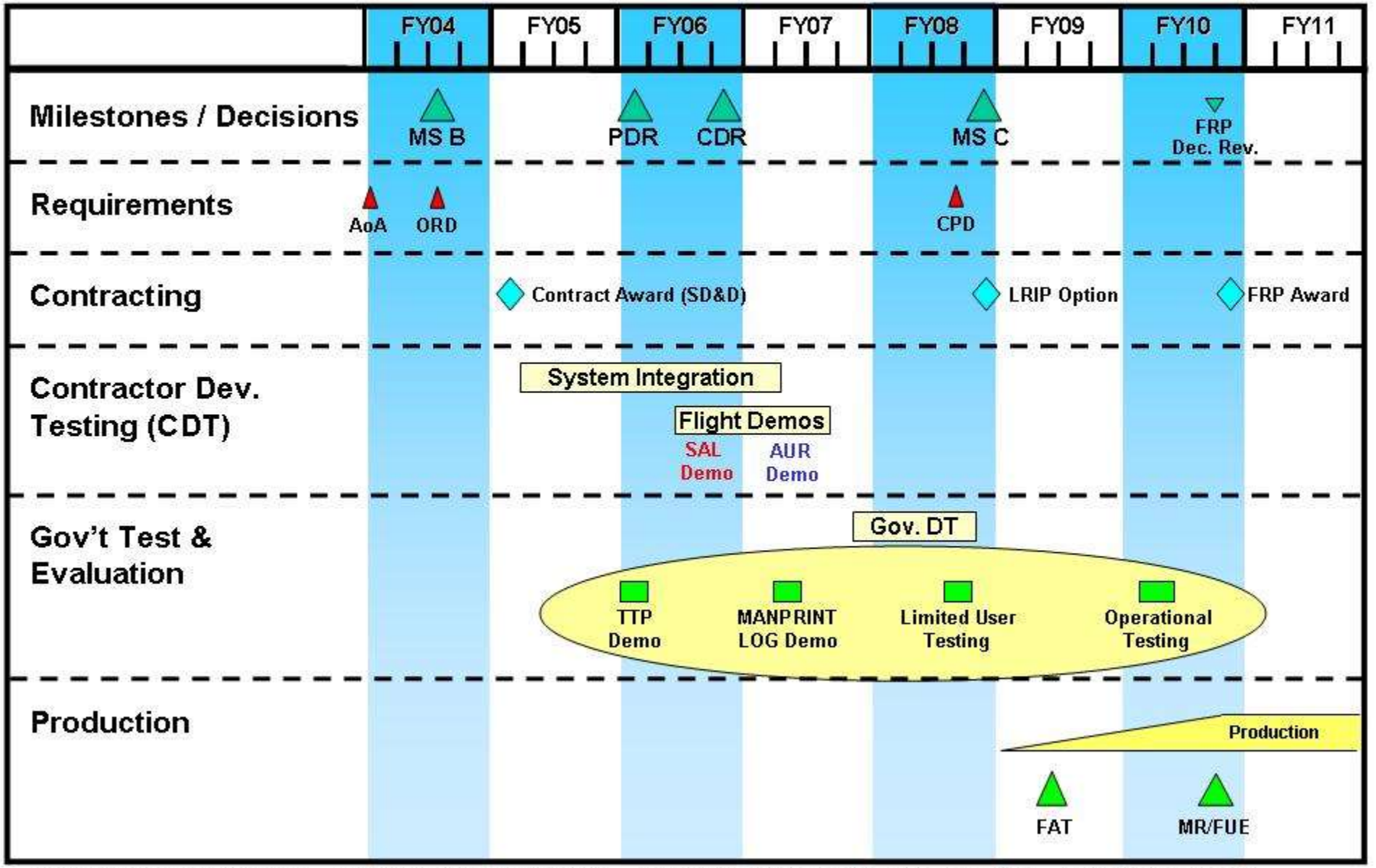
M1064

Vehicle Mounted 120mm Stryker MC

NLOS-Mortar (future)

PGMM
An Integral Part of Modern and Future Battalion Indirect Fire

Baseline PGMM (Increment I) Program Schedule



AoA: Analysis of Alternatives
FRP: Full Rate Production
TTP: Tactics Techniques Proc.
AUR: All Up Round
Gov. DT: Government Development Testing
FAT: First Article Test
MR: Material Release
FUE: First Unit Equipped

Problem Statement

- Reduced Combat Effectiveness without Adequate Training Program
- No Affordable or Practical PGMM Training System is Available
  - Current Options
    - Firing Tactical Laser Guided PGMM (Hundreds of Rounds/Year x $10K/Round)
    - No Training (Not an Option)
    - Manual Process @ Training Center (not representative of Tactical)

Project Goals

- Develop an integrated plan for PGMM Training Concepts that can:
  - Effectively Train the Mortar Crew
    - Preparation, drop firing, and misfiring procedures
  - Training of Forward Observer to Adequately Designate Targets within the PGMM Firing Mission Timelines
  - Communication Links between FO, Battalion FSE, FDC and Mortar Crew
  - Achieve a 50% minimum overall Cost Avoidance through Reduced Tactical PGMM Firing
    - Cost effective training concept alternatives.

NOTES: FSE: Fire Support Element FDC: Fire Direction Center FO: Forward Observer

PGMM Training Q$SR

Type		
		Engineering
		Production
		Business
	x	Management

Project Summary:

Develop an integrated plan for PGMM Training Concepts that can:

- **Effectively Train the Mortar Crew**
  - **Preparation, drop firing, and misfiring procedures**
- **Train Forward Observer to Adequately Designate Targets within the PGMM Firing Mission Timelines**
- **Identify Communication Links**
- **Achieve a 50% minimum overall Cost Avoidance through Reduced Tactical PGMM Firing.**

Quality or Customer Satisfaction	*Co$t*
Provide the Warfighter with a viable low cost training solution to achieve indirect fire precision strike capability.	**Potential savings $10.24M/year of Training (10 year product life cycle can save over $100M in training costs)**
Project Successfully laid out Approach, Methodology and Plan. **(Follow-on Project recommended to Implement Training Concept into Program SDD)**	**FMEA evidenced medium risk areas.** **FO Trainer; Virtual Simulator** **QFD identified Training Concept leverage points to maintain affordable approach.**
Schedule	*Risk*

PGMM Training Implementation

Implementing PGMM Training

- **New Equipment Training (NET)**
  - Update documents to include PGMM and operating Tactics, Techniques and Procedures.
  - Develop physical mock up of PGMM for handling, programming, and visual reference.
  - Text / Video Course instruction training material.

- **Institutional Training**
  - Develop classroom training.
  - Integrate CFFT / Mortars / MFCS / PGMM / Laser Designation for classroom training.

- **Virtual Training**
  - Understand / Develop Tactics, Techniques & Procedures (TTPs).
  - Integrate CFFT / Mortars / MFCS / PGMM / Laser Designation for virtual training.
  - Integrate PGMM Trainer with MFCS Gun & FDC training aids and devices.
  - Develop Models and Simulations as part of Virtual Training resources to support Live Training.
  - Virtually train Gunner, FDC, and Forward Observer in a closed loop system, for collective unit training.

- **Collective (Live and Combined Arms)**
  - Develop Embedded Training Instrumentation (MFCS).
  - Provide a PGMM training capability at the Combat Training Center (CTC) .

Who We Will Be Training

- Fire Direction Specialist (MOS 13F)
- Indirect Fire Infantryman (MOS 11C)
- Ammunition Specialist (MOS 55B)
- Fire Direction Center (FDC) Personnel
- EOD

Mortar Mission Training Requirements

- Operate in Centralized or Decentralized C3 Modes
- Centralized: Through Battalion Fire Support Element
- Decentralized: Sensor to FDC and/or Gun

PGMM Call for Fire

Forward Observer

Company FIST[1]

Battalion FSO[2]

Mortar FDC[3]

Mortar Squad

1 Target Identified

8 Shot Out

9 Lase Target

10 End of Mission, BDA[4]

Advanced Field Artillery Tactical Data System (AFATDS)

Mortar Fire Control System (MFCS)

2 Call For Fire

M95 MFCS

6 Shot Over

7 Lase Target

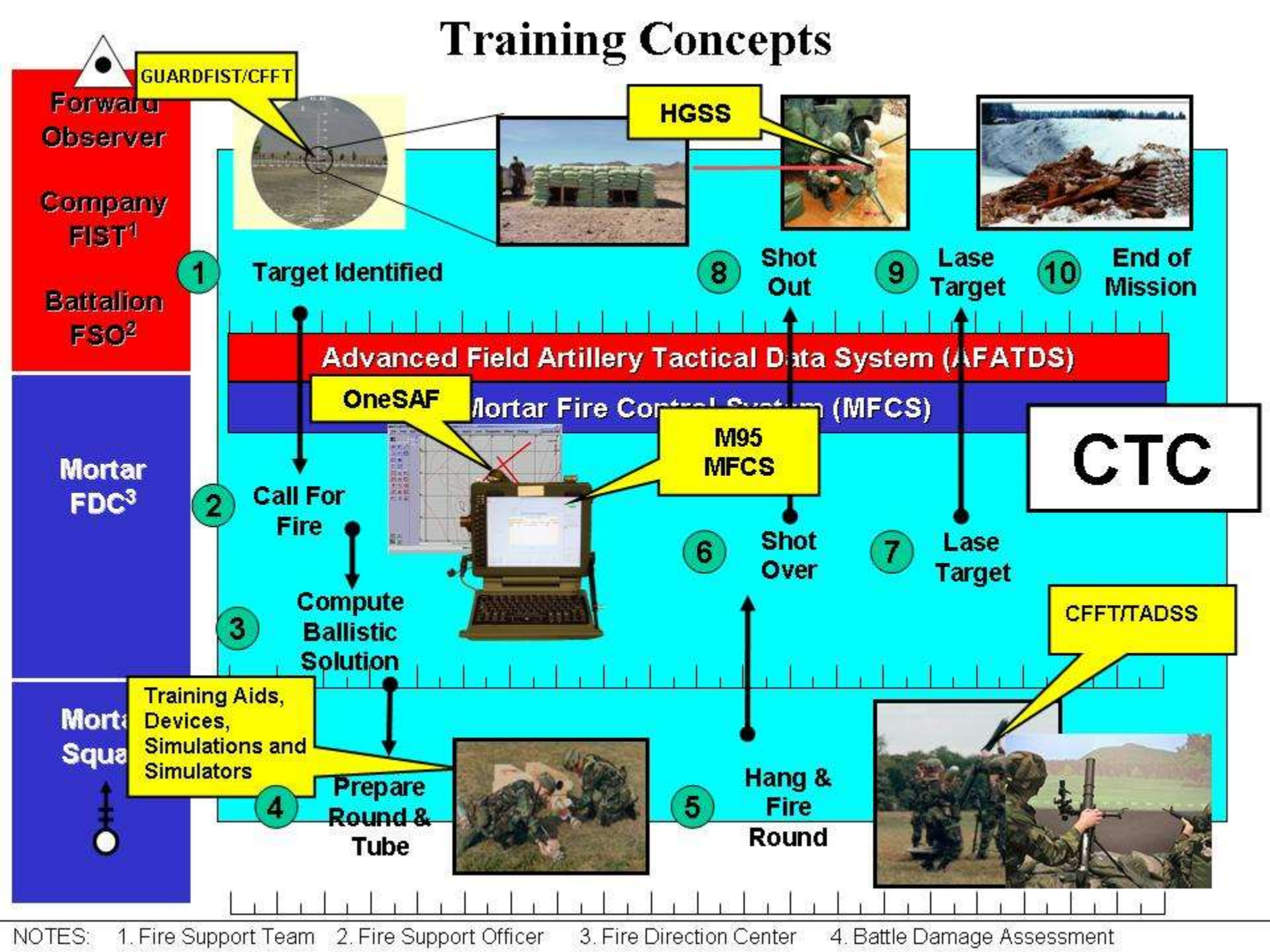
3 Compute Ballistic Solution

4 Prepare Round & Tube

5 Hang & Fire Round

NOTES: 1. Fire Support Team 2. Fire Support Officer 3. Fire Direction Center 4. Battle Damage Assessment

Training Concepts



NOTES: 1. Fire Support Team 2. Fire Support Officer 3. Fire Direction Center 4. Battle Damage Assessment

Summary

- US Army investing in Precision Munitions for Close Combat (Mortar Systems)
  - Requirements are Approved
  - Program is Fully Funded, PGMM SDD Awarded 01Dec04
- Result will be Leap Ahead Precision Effects Capabilities for the Maneuver Commander
- Training is key to PGMM Affordability and Performance
- Collective/Combined Arms Training Requirements are being defined

6th Annual Mortars Conference October 19-21, 2005
Headquarters Plaza Hotel, Morristown NJ

AUTOMATED AMMUNITION IDENTIFICATION

What was that anyway?

David F. Pouliot

United Defense LP

(540) 663-1510 **david.pouliot@udlp.com**

Automated Ammo ID

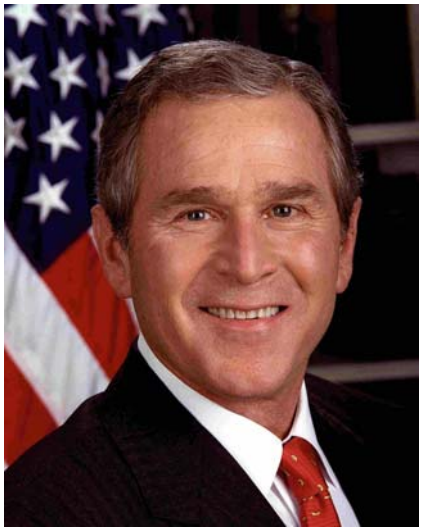
United Defense

- Problem Definition
- Requirements
- Technology
- 2D Data Matrix Coding
- Marking Ammunition
- Lessons Learned
- Questions
  - Photo Test

1

2

3



4

5

What is the problem?

United Defense

- New ammunition utilizes high energy propelling charges to achieve extended range.
- The latest upgrades to the 5-Inch Naval gun (MK45 Mod 4) allow it to handle increased energy.
  - Chamber Pressures
  - Recoil Stroke
  - Muzzle Energy increased from 10MJ to 18MJ
- Existing MK45 Mod 1 & 2 guns can not handle this increased energy.
- Existing projectiles are not qualified for these launch forces.

Problem Statement

United Defense

- If an extended range propelling charge is accidentally loaded into / fired from a Mod 1 or 2 gun the resulting overpressure could be catastrophic.
- If an existing projectile is loaded with an extended range propelling charge and fired from a Mod 4 gun, the 'set back' forces will exceed the limits of the projectile.
  - 'In-bore' explosion
  - Unknown flight characteristics

Stated Requirements

United Defense

Provide an automated Ammunition Identification (Ammo ID) capability to:

- Preclude the inadvertent loading of high energy propelling charges behind incompatible projectiles in Mod 4 guns
- Preclude the loading of high energy propelling charges in existing Mod 1 and Mod 2 guns

Derived Requirements

United Defense

- **The Ammo ID capability must be compatible with existing ammunition already in the fleet**
  - **Must be able to distinguish between existing ammunition and new extended range rounds**
- **The Ammo ID capability must have adequate growth potential to support expanded weapon system functionality**
  - **Improved Gun Fire Control ballistic predictions**

5” Gun Ammunition

United Defense

Typical Propelling Charge ~ 40lbs

Typical Projectile ~ 70lbs

Typical Projectile Stowage

Typical Prop Charge Stowage

Ammunition Loading

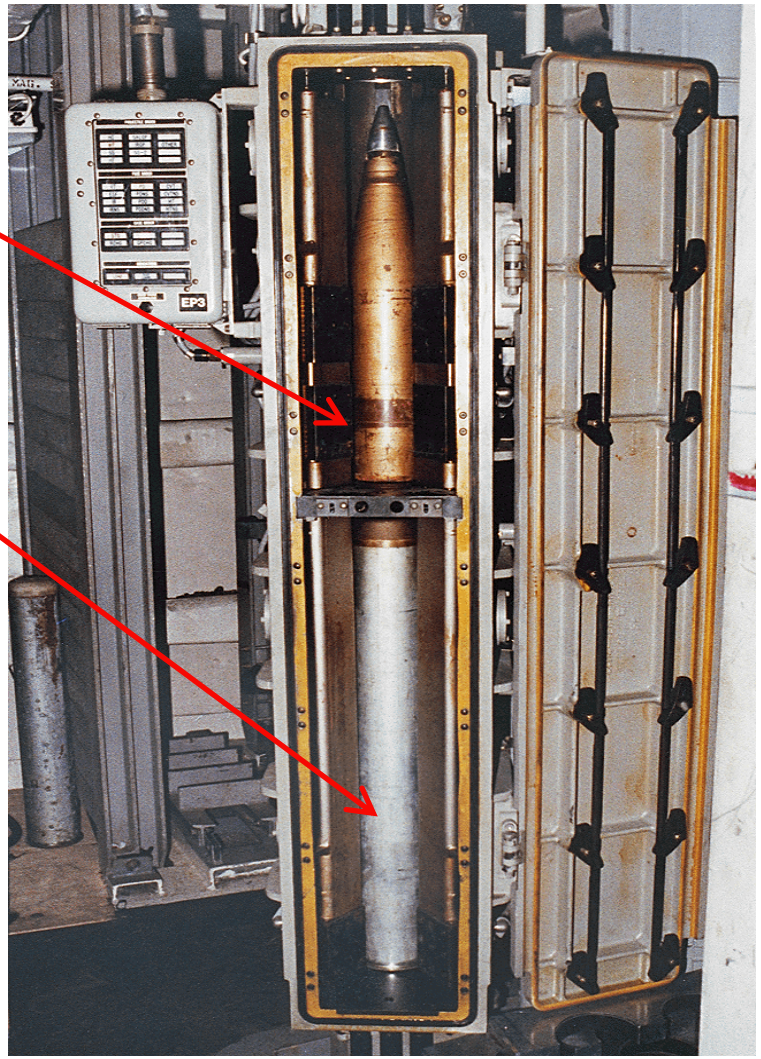
United Defense

Projectile Loading Station in Magazine

Propelling Charge Loading Station in Magazine

Maximum Rate of Fire for the Gun System is 20 Rounds per Minute

- Magazine crew can match maximum rate for ~ 10 minutes
- Sustained reload rate drops to about 8-10 rounds per minute



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Ammo ID Technologies

United Defense

- Human / Procedures
- Automatic Color Detection
- RF Tags
- Standard 1D Bar Codes
- 2D Data Matrix

Ammo ID Technologies

United Defense

- **Human / Procedural**
  - **Logistic Control**
    - **Do not issue high energy propelling charges to Mod 1 or 2 ships**
  - **Use color coded closure plugs**
    - **Red = ERGM**
    - **Green = Extended Range Cargo or Hi-Frag**
    - **White = Standard Propelling Charge**
  - **Expected human error of 1/1000**

Ammo ID Technologies

United Defense

- **Automatic Color Detection Sensors**
  - **Detects propelling charge plug color or applied color band on projectile or charge**
  - **May have issue with existing projectiles**
    - **Several colors already used**
    - **System needs to identify existing versus new rounds**
  - **Very limited – no growth potential**

Ammo ID Technologies

United Defense

- **RF Identification Tags**
  - **Operational problems in shipboard EMI environment**
  - **Difficult to incorporate into projectile design**
  - **No ability to distinguish between existing ammunition (no tag) and defective tags**

Ammo ID Technologies

United Defense

- **Standard 1D Bar Code**
  - **Unreliable / Poor read rate**
    - **Retail store experience**
  - **Numeric encoding requires data base cross reference**
    - **Adds to cost of ownership**

Ammo ID Technologies

United Defense

- **2D Data Matrix**
  - **Full ASCII encoding**
  - **Redundant Data / Error Correction**
  - **Provides Future Growth Potential**
  - **Selected by gun community**
    - **Mature technology / readily available**
    - **Straight forward integration into ammunition components**

2D Data Matrix Code

United Defense

- **ECC 200 Code Format**
  - **Incorporates Reed-Solomon Error Correction**
- **Consistent with ANSI AIM BC11 Data Matrix Symbology Specification**
- **22 X 22 Matrix Density Selected**
  - **0.55 inch square**
  - **43 encoded characters**

Encoded Data

United Defense

Characters		Data	Comment
1		Projectile / Charge Identifier	P/C/H
2-5	4	DoDIC Identification Code	Alpha/Num
6-8	3	Assembly Mark Number	Numeric
9-10	2	Assembly Mod Number	Numeric
11-19	9	National Item ID Number	Numeric
20-33	14	Ammunition Lot Number	ASCII
34-38	5	Weight (implied decimal .01)	Numeric
39-43	5	Spares	

Data Matrix Considerations

United Defense

- Symbol must be durable & high quality
- Must work regardless of ammunition component orientation in load station
  - Sailor does not have time to look for the data matrix
  - Band of identical code squares uniformly placed around each ammunition component
  - Multiple squares in Field-of-View of sensor
- Application rate must be compatible with projectile & propelling charge production lines
  - Four per minute

Data Matrix Marking Sample

United Defense

26 evenly spaced data matrix squares with English text printed below

PD3490420100480338 9CRA75D001-024B07000

DoDIC

Weight = 70.00 lbs

Assy Mark Number

14 Character Lot Number

Assy Mod Number

Projectile/Charge Indicator

9 Character National Item ID Number

Symbol Quality

United Defense

Initial Marking Quality

- Grade "A"
- Symbol Contrast ≥ 70%
- Print Growth ≤ ± 0.50
- Axial Nonuniformity ≤ 0.06
- Unused Error Corr. ≥ 62%

Sensor Capability

- Grade "C"
- Symbol Contrast ≥ 40%
- Print Growth ≤ ± 0.85
- Axial Nonuniformity ≤ 0.12
- Unused Error Corr. ≥ 0%

High quality initial markings provide for robust read capability taking into account degradation over time

Data Matrix Application Techniques

United Defense

- Stick-on Labels
- LASER Etching
- LASER Color Bond
- Ink Jet Printing
- Mechanical Stamping
- Silk Screen Ink

Application Techniques

United Defense

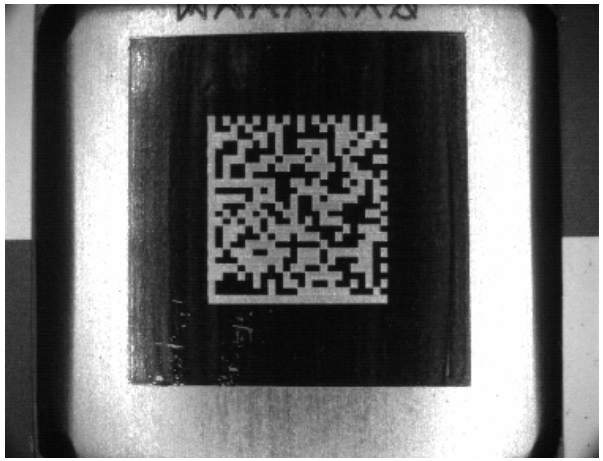
- **Stick-on Labels**
  - **Cheap, easy application**
  - **Tear off during handling**

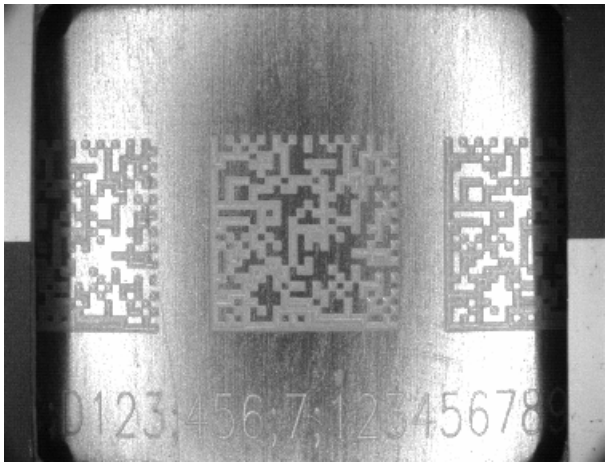
*** Labels were selected for use during development testing**

Application Techniques

United Defense

- **LASER Etching**
  - **Expensive Equipment**
  - **Very Slow Process**
    - **Estimated to take more than 5 seconds per data matrix square**





Application Techniques

United Defense

- **LASER Color Bond**
  - **Expensive Equipment**
  - **Very Slow Process**
    - **Estimated to take up to 60 seconds per data matrix square**

Application Techniques

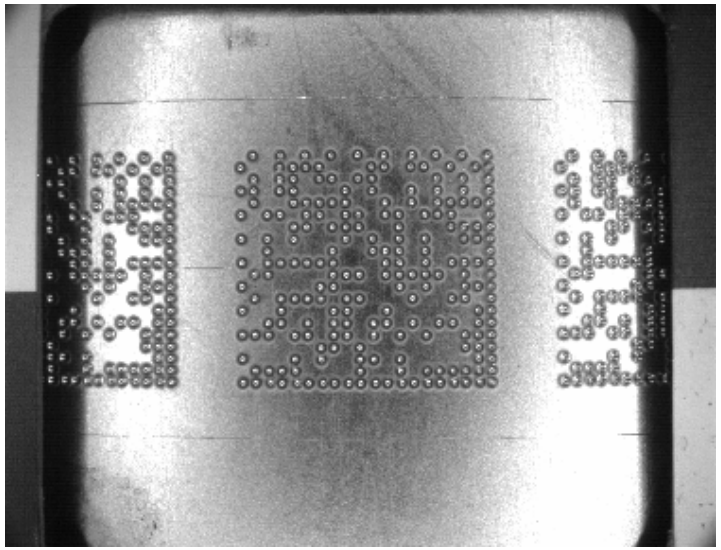
United Defense

- **Ink Jet Printing**
  - **Moderate Equipment Cost**
  - **Slow Process**
    - **Estimated to take 3 seconds per data matrix square**

Application Techniques

United Defense

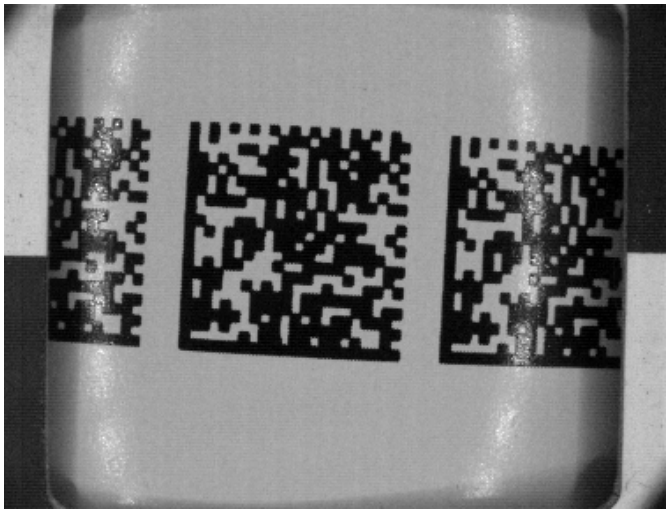
- **Mechanical Stamping**
  - **Low Contrast**
  - **Negative Impact on Environmental Resistance**
  - **Slow Process**
    - **Estimated to take about 25 seconds per data matrix square**



Application Techniques

United Defense

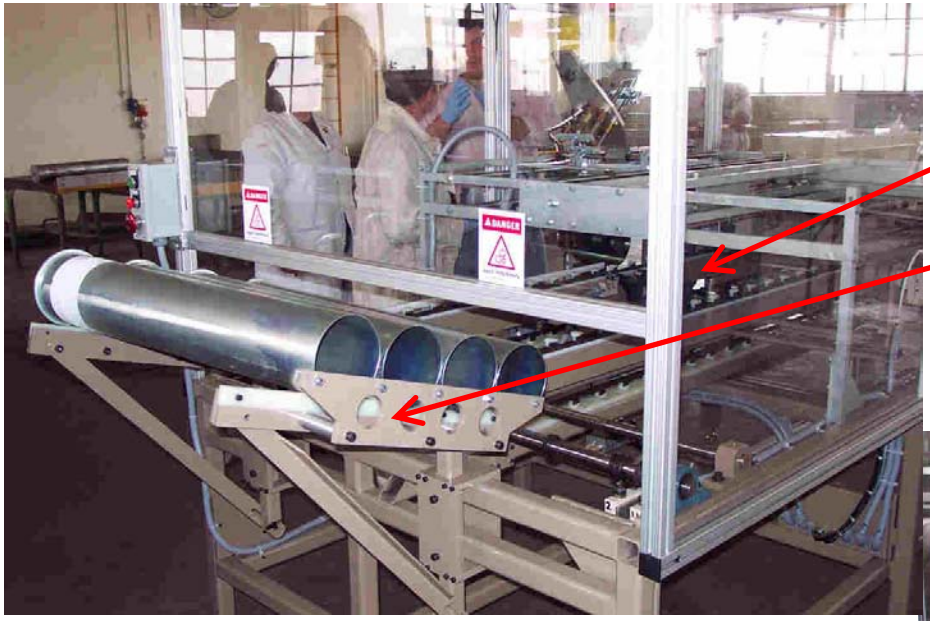
- **Silk Screened Ink**
  - **Moderate Equipment Cost**
  - **Very Fast Process**
    - **Estimated to take less than 0.1 second per data matrix square**



*** Silk screened ink was selected for production use**

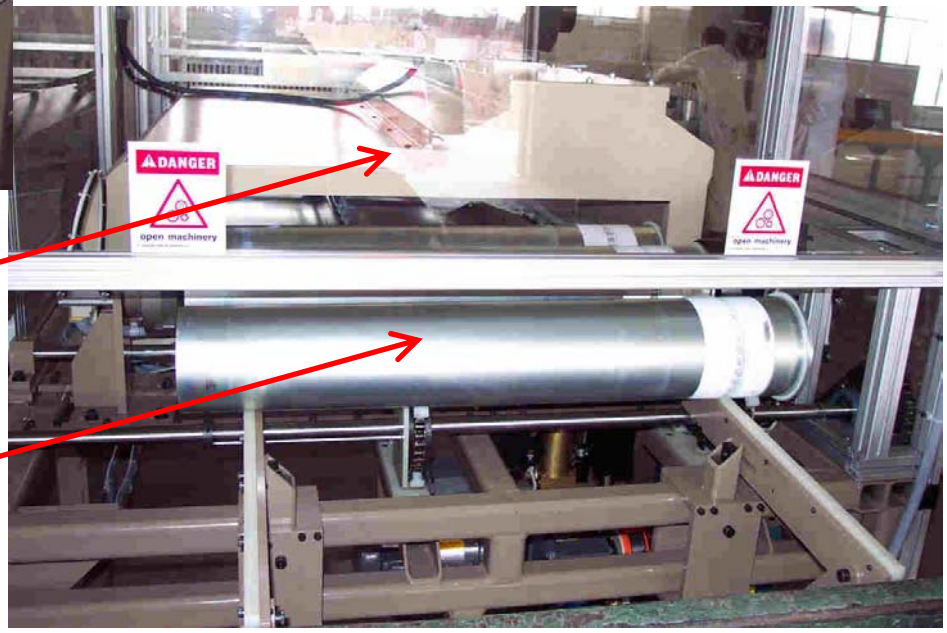
Prototype Marking Equipment

United Defense



Silk Screen Area

Propelling Charge Feed Area



Dryer Section

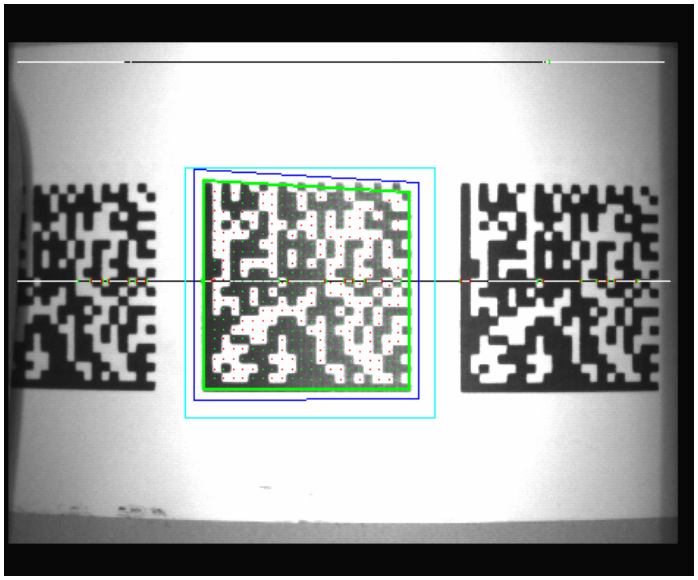
Propelling Charge Exit

Auto ID Sensors

United Defense

- **DVT Corporation Sensors**
  - **Five sensors used in gun mount, one sensor at each ammunition loading station**
    - **LED illumination**
    - **Robust 2D data matrix 'reader tool'**
    - **Less than 2 second inspection time**
    - **'Feature tools' able to discriminate damaged, unreadable tag from existing ammo with stenciled writing in field of view**
    - **Serial interface with gun mount control system**

DVT Model 630
"Custom COTS Sensor"



Auto ID Lessons Learned

United Defense

- Must be mature technology
  - Readily available / moderate cost
- Application method must be able to meet ammunition production rates
- System design must support anticipated future growth
- Auto ID system must be robust
  - High and reliable read rate
  - Able to distinguish ‘bad tag’ from ‘no tag’
  - Able to support maximum gun mount loading rate without delay

Automated Ammo ID

United Defense

QUESTIONS ??

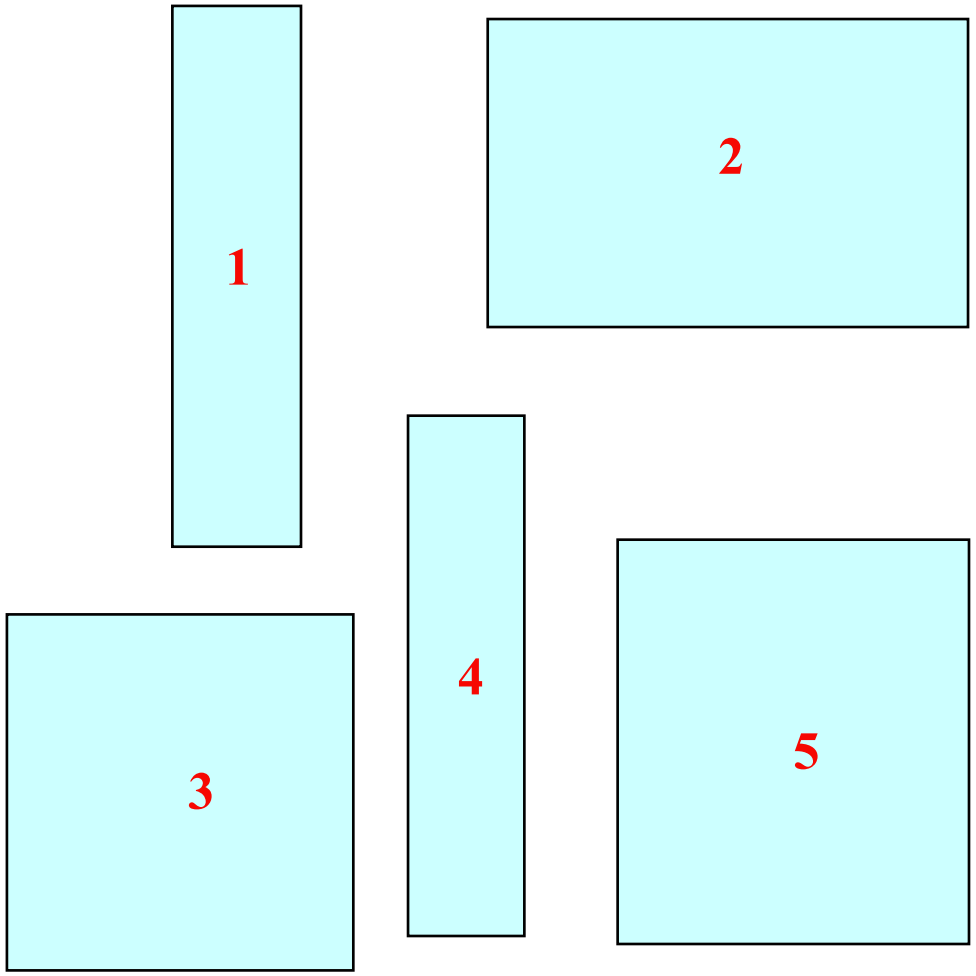
President George W. Bush

Standard Propelling Charge

Pamela Anderson

1965 Mustang

High Energy Propelling Charge



Now its time for the Coors Lite!

PROJECT MANAGER MANEUVER AMMUNITION SYSTEMS

Direct Fire Ammunition Lessons Learned:

"More Than Just Impacts on Bullets"

COL Mark Rider

28 APR 05

Reliable, Precise, Lethal

Take Aways

- **Strategic Ammunition Environment: Dramatic Increase In Demand for Direct Fire Ammunition**

- **Lessons Learned / Impacts Include More Than Just Bullets……**
  - **Production Facilities**
  - **Products**
  - **Life Cycle Management**

Agenda

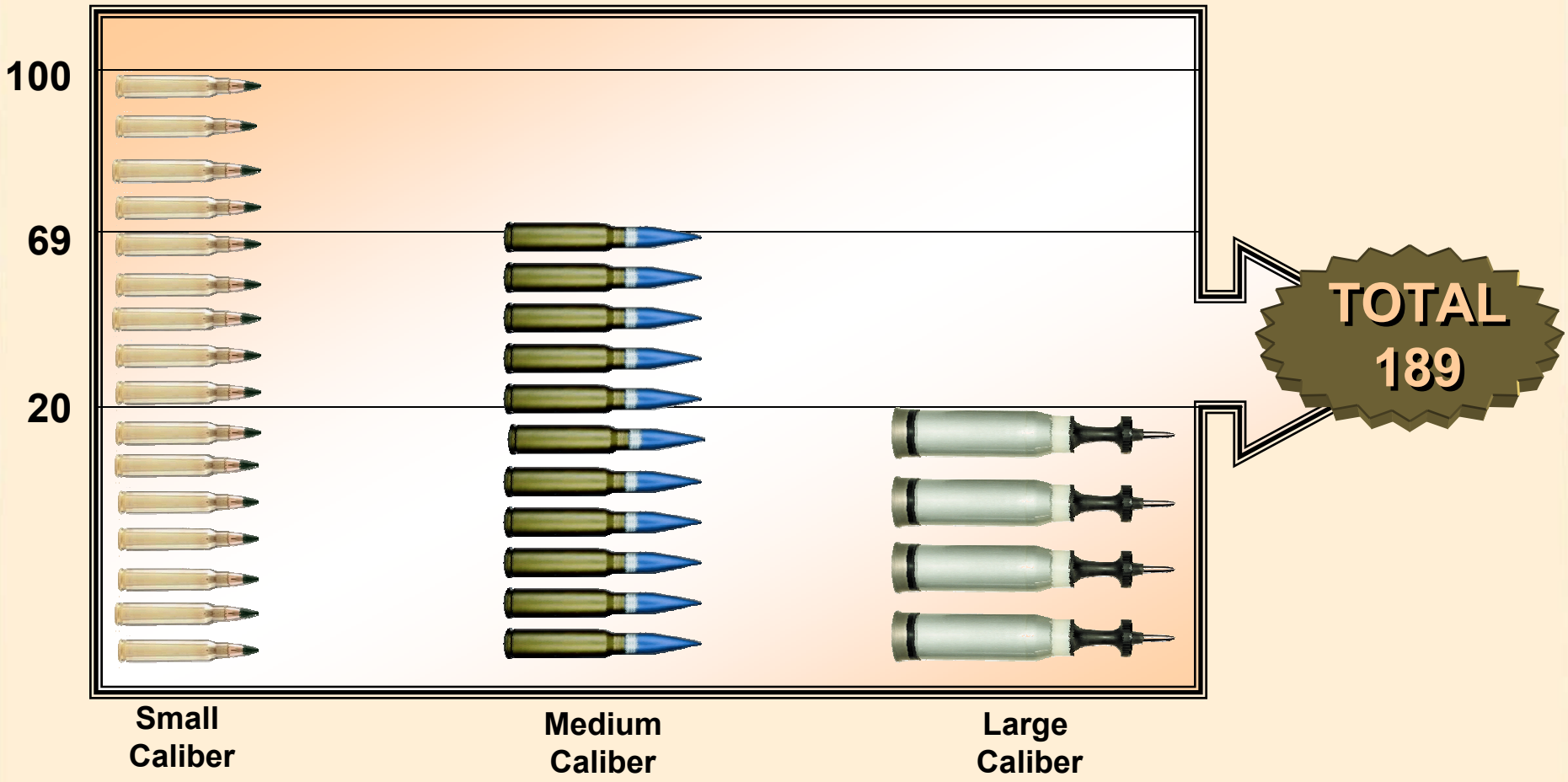
- Mission
- Scope
- Strategic Ammunition Environment
- Ammunition Areas and Lessons Learned
- Summary

PM-MAS Mission

PM MAS Provides Direct Fire Combat And Training Ammunition Capabilities To Warfighters (Army, Navy, Air Force, Marines) And Government Agencies To Support Dismounted Soldiers, Combat Vehicles, Helicopters, Naval Vessels, And High Performance Aircraft. The PM Does This Through Life Cycle Program Management Of Ammunition In The Following Categories:

Small Caliber
Medium Caliber
Large Caliber
Smart Munitions

Ammunition Products



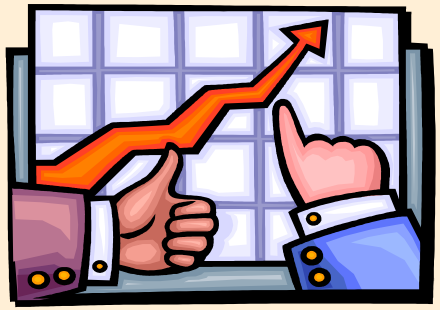
PM MAS
FY05 Production Quantities Projection

Small Caliber (1710M)	5.56MM	1,271M
	7.62MM	273M
	.50 Cal	80M
	9MM	75M
	MISCELLANEOUS	11M
Medium Caliber (21.5M)	20MM	4M
	25MM	1M
	30MM	5.5M
	40MM	11M
Large Caliber (233K)	105MM	.02M
	120MM TRAINING	.2M
	120MM TACTICAL	.013M

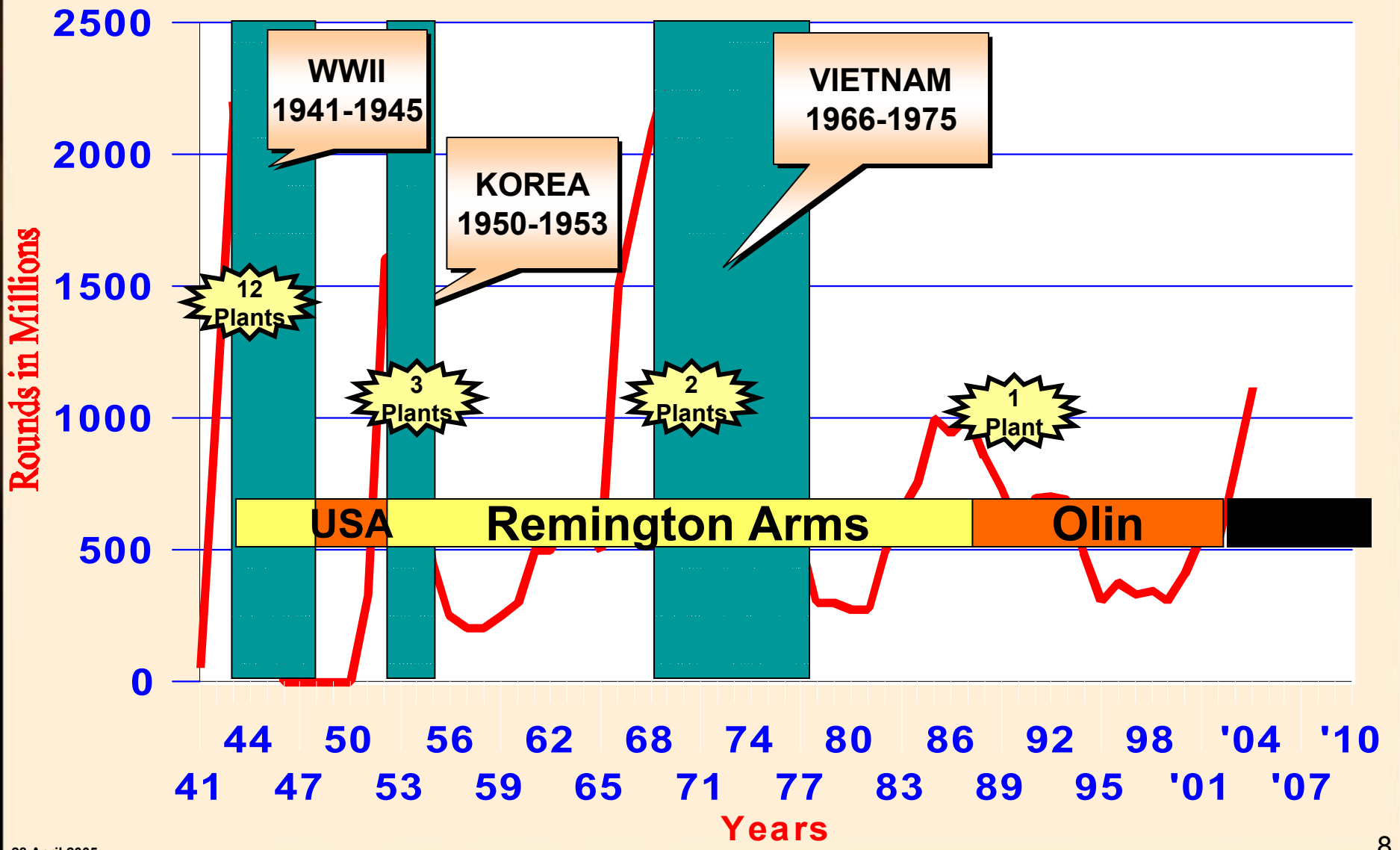
Strategic Ammunition Environment

- **Pre-FY2001:**
  - **Relatively Low Production of Ammunition**
  - **Ammunition Stocks Drawn Down**

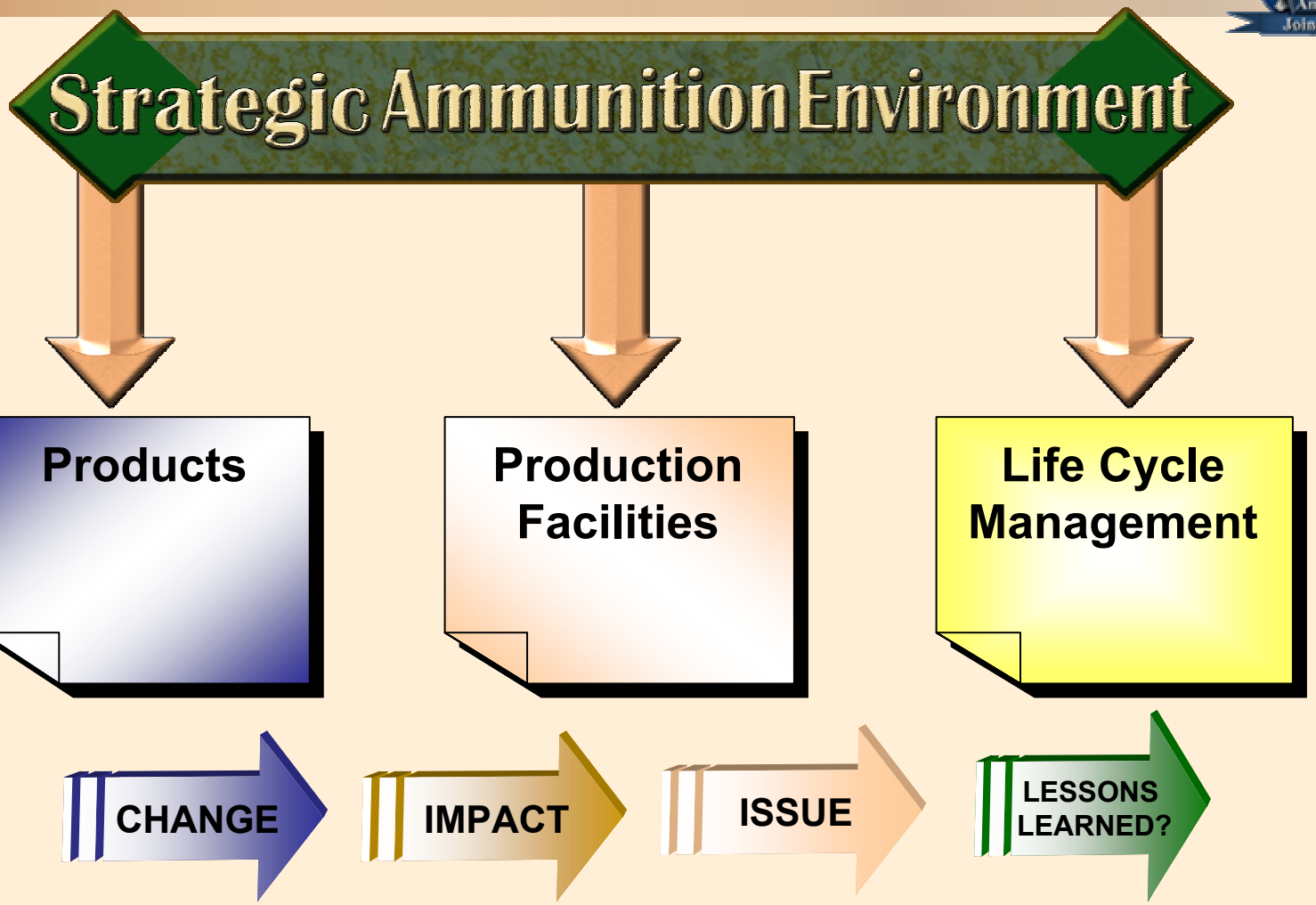
- **FY2001 To Now:**
  - **Dramatic Increase in Demand/Requirements for Direct Fire Ammunition**
  - **Requirements Drivers:**
    - **Training**
      - **Greater Emphasis on Live Fire Training**
      - **Mobilization Impacts**
      - **More Personnel Being Trained to Higher Standards**
    - **Operations**
      - **Support and Forward Positioning of Ammunition**
      - **Changes in Tactics Causing Changes in Requirements**



Strategic Ammunition Environment
Lake City Production History



Ammunition Areas



Lessons Learned in All Three Areas:
"Impacts to More Than Just Bullets"

Production Facilities

Strategic Ammunition Environment

CHANGE

Dramatic Production Ramp Up / Start Up

IMPACT

Designs (TDP), Process, Personnel, Equipment
(Anything But Steady State!)

ISSUE

Initial Quality/Delivery Issues

LESSONS LEARNED?

- Must Focus on Process/Personnel as Much as Machinery!
  - Review/Rehearse the Process Repeatedly
  - Stabilize Critical Machine Operators Early
  - Over Plan and Over Execute Training and Process Analyses!
  - Increased Surveillance, Checks of Operations

Must Have a Robust Change Management Strategy!

Production Facilities

Strategic Ammunition Environment

CHANGE

Dramatic Production Ramp Up / Start Up (Small Caliber Specific)

IMPACT

Primarily Only the Organic Plant (Lake City) was Supplying Rounds

ISSUE

Not Enough Rounds from Organic Plant When Needed

LESSONS LEARNED?

- Outsourcing to Commercial Sector in Large Quantities To Augment the Organic Base is Viable and Works
  - Used Urgent Buys to Provide Needed Rounds
  - Commercial Base is Capable
  - Mitigates Risk Through Geographic Separation and Use of Other Vendors

Production Facilities

Strategic Ammunition Environment

CHANGE

Dramatic Production Ramp Up / Start Up (Small Caliber Specific)

IMPACT

Continuous Production at Organic Facility (Lake City)

ISSUE

Equipment is Very Old; Being Used Around the Clock

LESSONS LEARNED?

- Modernization Funding is Critical to Production Readiness
  - Equipment Failure is a Real Risk; Can Not Afford Production Stoppages
  - Must Fund Needed Modernization of Facility
  - Working Issue Aggressively With Pentagon Now

Products

Strategic Ammunition Environment

CHANGE

Lower Demand for KE Tank Rounds/Higher Demand for Multi-Purpose

IMPACT

KE Rounds Being Sent to the Rear, Multi-Purpose Rounds Forward

ISSUE

FY2000 - Last Time the Army Produced Multi-Purpose, Other Capabilities?

LESSONS LEARNED?

- Operators Must Have Flexibility to Quickly Mission Organize Ammunition
- Need for Capabilities Other Than KE – M1028 Anti-Personnel Round
- Highlights Need for Common, Multi-Purpose Round
  - Less Specialty Rounds
  - Easier to Manage Operations and Logistics

Products

Strategic Ammunition Environment

CHANGE

Increased Armed Convoy Operations

IMPACT

Increase in .50 Caliber (Armor Piercing and Armor Piercing Incendiary) and 7.62MM Requirements

ISSUE

Low Stocks, Low Production Rates, Oldest Manufacturing Equipment

LESSONS LEARNED?

- Must Stockpile Ammunition ("Iron Mountain"), Especially With These Rounds
- Need More Vendors With Capability to Produce .50 Caliber Armor Piercing/Incendiary
- Must Modernize Equipment at Organic Facility (Oldest in Plant)
- Limited Trace and Explosive War Head Capability in Commercial Sector

Life Cycle Management

Strategic Ammunition Environment

CHANGE — War Time Operations

IMPACT — Large Demand and Inventory in Theater

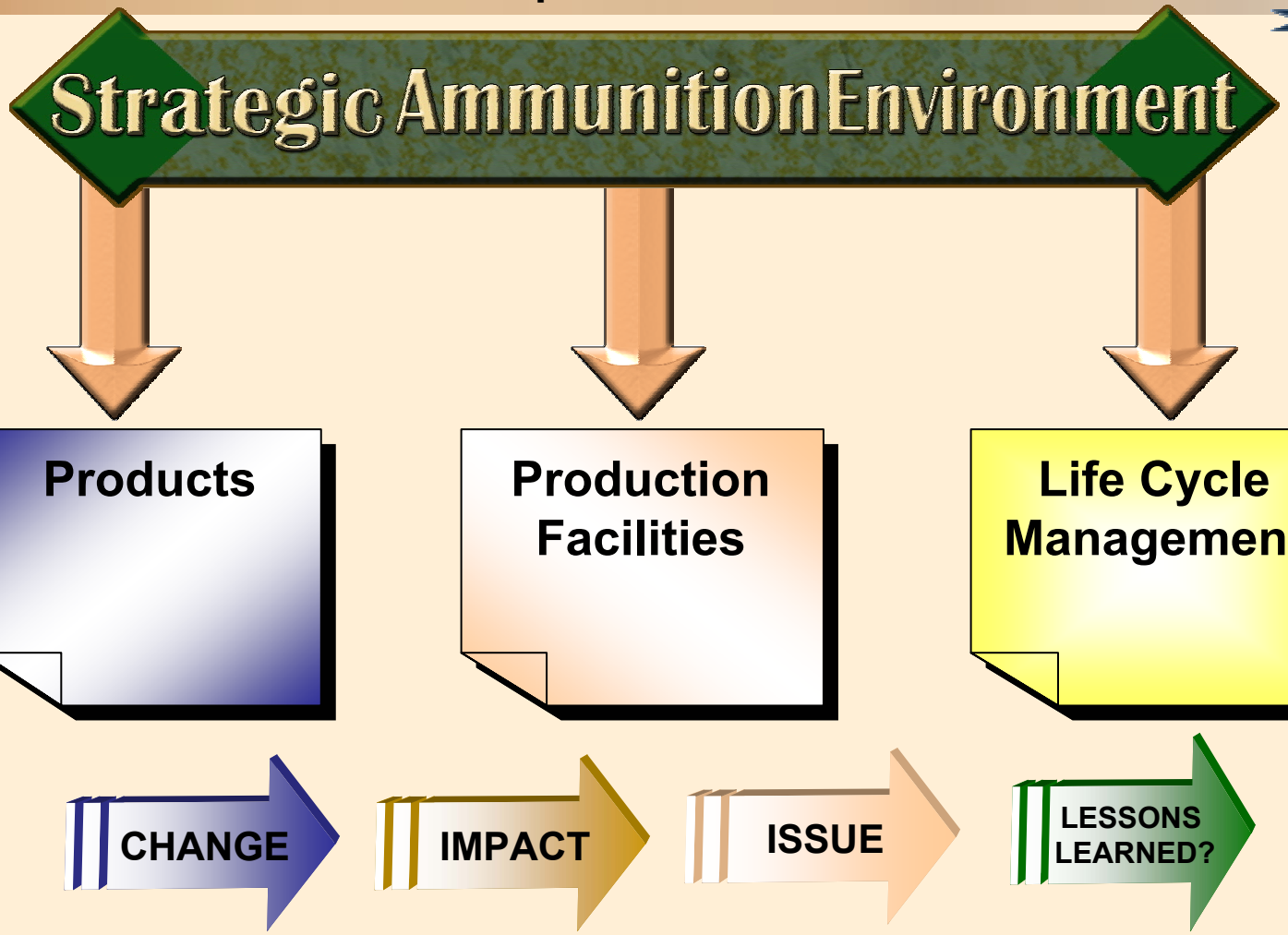
ISSUE — Asset Visibility; No Totally Integrated Receipt, Accounting, and Tracking System for Ammunition

LESSONS LEARNED?

- Must Develop Integrated Accounting and Visibility System for Ammunition
  - Need to Minimize Paper Records and Exploit Advances in Supply Tracking Technology
  - Must be Designed for Both War Time and Peace Time Use
- Requirements – Must Have Prognostics Capability
- War Reserve Stockpile Commitment

Ammunition Areas

"Lessons Learned / Impacts to More Than Just Bullets"



What Happens Next? Will Lessons be Learned?

Summary

- **Strategic Ammunition Environment: Dramatic Increase In Demand for Direct Fire Ammunition**

- **Lessons Learned / Impacts Include More Than Just Bullets……**
  - **Production Facilities**
  - **Products**
  - **Life Cycle Management**

U.S. Army ARDEC Overview & Special Weapon Observation Reconnaissance Direct-Action System (SWORDS)

Presented to:

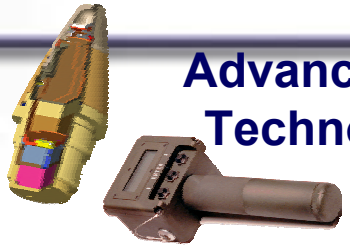
NDIA 40th Annual Armament Systems: Guns-Ammo-Rockets-Missiles Conference

28 April 2005

Anthony J. Sebasto
U.S. Army Armament Research, Development, and Engineering Center (ARDEC)
asebasto@pica.army.mil
973-724-6198

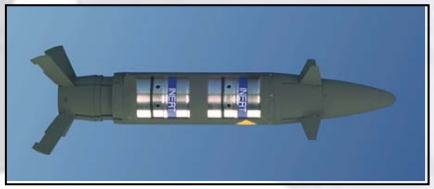
ARDEC Mission

Artillery & Mortar Systems



Advanced Fuze Technologies

Special Operations Weapons & Demolitions



Conventional & Smart Munitions

R&D

DEMIL

PROD

SUPPORT TOTAL LIFE CYCLE

FIELD SUPPORT

Advanced Energetics & Warhead Development

Combat Vehicle Armaments & Fire Control

Logistics R&D

Non-Lethal Technologies

Small Arms

Providing over 90% of the Army's Lethality

ARDEC at a Glance

- Established “Center of Mass” for Armament Systems and Munitions for Joint Services
- ARDEC Personnel = 2679; 590 new hires since FY99
- $100M invested in modern experimental R&D facilities since mid-90’s
- Proven track-record supporting transition of technologies to the field; since Nov 03.....
  - 9 Type Classifications
  - 16 Material Releases (MR)
  - 10 Urgent MR (17 since early FY03)
- Strong partnerships with Industry, Academia, and other Government agencies.
- In-house rapid prototyping initiatives overcoming production problems or providing new desired capabilities to field in near term
- >$125M Tech Base portfolio addressing Joint needs

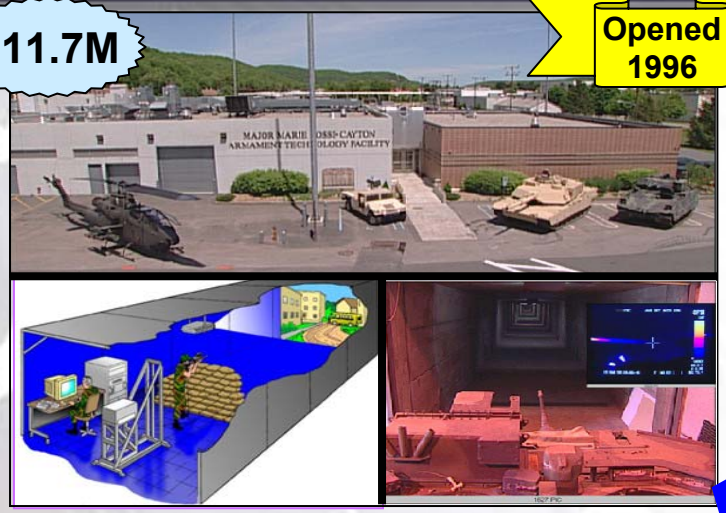
2004 Army Large R&D Lab of the Year

World Class Facilities

Most Recent in Operation

$11.7M

Opened 1996



Armament Technology Facility

$8.8M

Opened 2000

Davidson Advanced Warhead Development Facility

~$45M in Facility Modernization invested over last 10yrs

$8.4M

Opened 2003

Precision Armaments Laboratory

$15.5M

Opened 2005

Armament Software Engineering Center

World Class Facilities

Breaking "old" grounds

High Energy Propellant Formulation Facility

- MCA Funded - $17.7M
- Planned Completion – FY07
- 45,000 ft^2 -
  - Propellant Pilot Plant /
  - Characterization Laboratories /
  - Magazine Storage / Offices

Pyrotechnic Research & Technology Complex

- MCA Funded - $9.9M
- Planned Completion – FY07
- 33,000 ft^2 –
  - Engineering Offices & Laboratories
  - Pilot manufacturing facility
  - Energetic stowage

Actual Building Concept Available May 05

Explosives R&D Loading Facility

- MCA Funded - $8.0M
- Groundbreaking Dec 05; Completion – FY07
- 28,000 ft^2 –
  - Melt Pour Operations & Engineering
  - Climate Controlling Machining
  - Explosive Pressing, Cast Cure, & X-Ray

Type Classification & Material Releases
Some Examples - FY04 to Present

Type Classification Items

- M85 Remote Activation Munitions System Trainer
- M111 Improved Position, Azimuth Determining System
- M192 Lightweight Ground Mount
- M240H- 7.62mm Aviation Machine Gun (Aviation Version)
- M255A1 Flechette Warhead, 2.75 Inch Rocket
- MK281 Cartridge, 40mm TP-T
- M393A3/M467A1 Cartridges, Tank 105mm
- HE441D RS 84mm Munition
- HEAT551C RS 84mm Munition

Materiel Release (MR) Items

- XM101 Common remotely Operated Weapon Stations (CROWS)
- M930E1 120mm Illuminating Mortar Cartridge
- M19/M20 Modernized Demolition Initiator
- CHARGE, PROPELLING, 155MM: M232 (MACS)
- Cartridge, 60mm: Smoke, WP, M722A1 w/ Fuze PD/DLY M783
- M769, 60mm, Full Range Practice Cartridge (FRPC)
- M829A3, Cartridge, 120mm, Armor Piercing, Fin Stabilized, Discarding Sabot with Tracer (APFSDS-T)
- M879, 81mm, Full Range Practice Cartridge (FRPC)
- M1155 Portable Inductive Artillery Fuze Setter (PIAFS)
- M303 Special Operations Forces Demo Kit
- M95/M96 Mortar Fire Control System
- Cartridge, 9mm, Jacketed Hollow-Point,
- M255A1 Flechette Warhead, 2.75” Rocket
- MK399 Mod 1 Point Detonating/Delay Fuze

Urgent MR Items

- XM32 Lightweight Handheld Mortar Ballistic Computer
- M107 Cal .50 Long Range Sniper Rifle (LRSR)
- M211 and M212 Flare: Countermeasure
- Non-Lethal Capabilities Sets
- AT4 Confined Space High Performance Weapon
- MP5-A5 9mm Submachinegun
- Lightweight Shotgun System
- M203 Grenade Launcher (GL) Day/Night Sight (DNS)
- Vehicle Lightweight Arresting Device (VLAD)
- X26E Advanced Taser Weapon and Associated Equipment

Supporting Transition of Technologies to Production/Field During War Time

Urgent Fieldings

Some examples

AT-4 Comfined Space (CS)

- Enables safe firing in MOUT environments
- Same performance as AT-4
- ~800 systems to Army and SOCOM FY03/04

M26/X26E TASER

M26 Advanced Taser

X26E Taser/
M4 Adaptor

- M26 is modified COTS
- X26E provides readily available non-lethal capability to XM-4 carbine
- 42 M26 & 350 X26E Tasers fielded since Jun 03

Gunfire Detection System (GDS)

- Acoustically locate small arm fire origins
  - Provides azimuth, elevation & range
  - 360 degree coverage
- >100 systems fielded to Army and SOCOM since Aug 03

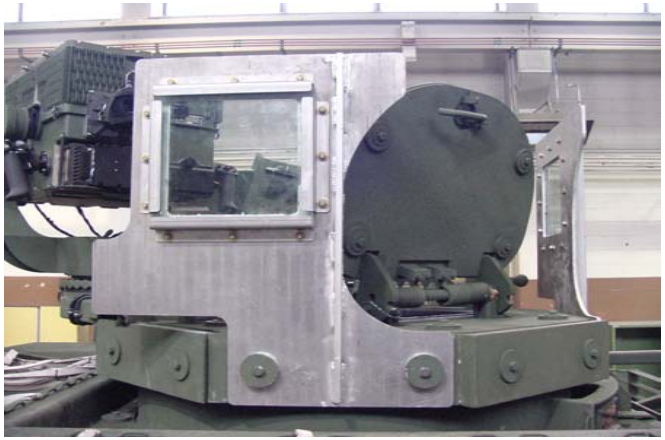
M211/212 Countermeasure Flares

- Broadens countermeasure signature to defeat all fielded Surface-to-Air Missile (SAM) Threats
- > 65,000 Flares fielded to Army & Air Force since Jan 03

Rapid Prototyping Initiatives

Examples Supporting Production Requirements

Stryker Ballistic Shield



- **Lightweight (145lb) Cupola mounted ballistic titanium protection w/armor windows**
- **Leverages ARDEC success from Titanium Welding Manufacturing Technology Program**
- **Ensures weapons maneuverability**
- **Production/fielding of 136 kits for Army's Stryker Brigade underway; 70 kits produced and shipped**

M54A1 Burster Tube Loading

ARDEC Load Process

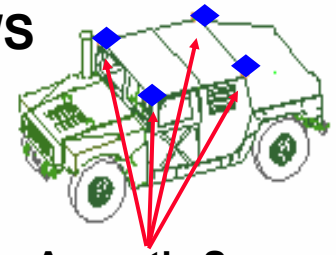
155mm M110A2 WP Smoke Projectile

- **Problem: M54A1 production problems impacted fielding of M110A2 to USMC**
- **ARDEC developed new melt pour & controlled cooling process**
- **7000 Burster Tubes loaded/delivered by ARDEC to Pine Bluff by May 05**
- **ARDEC executing new requirement for additional 7000 burster tubes**
- **Technology transfer of ARDEC process to industry underway**

Rapid Prototyping Initiatives

Examples of "Tech Push" for Early User Demo's

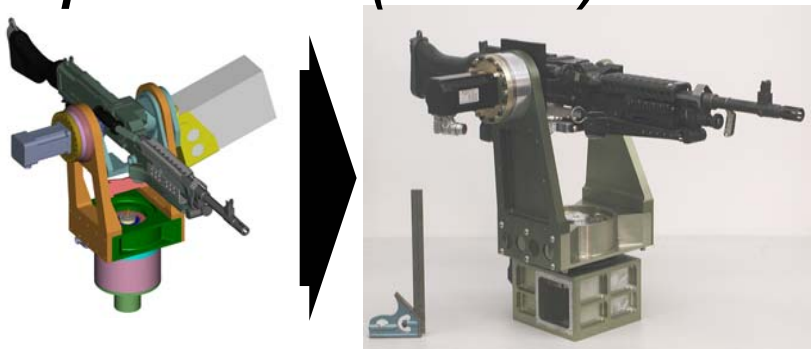
Remote Weapon Counter Sniper System



Acoustic Sensor Array x 4

- Joint ARDEC, AMC-FAST, PM-Soldier Weapons (PM-SW), & Industry Program
- Integrates 360º acoustic detection & location with remote weapon station
- Automatic or manual weapon position
- On-the-move weapon position updates
- USARPAC evaluation in CONUS and Limited Safety Release May/Jun 05
- ARDEC & PM working path ahead for evaluations in Iraq

Picatinny Lightweight Remote Weapon Station (PLRWS)



- Joint ARDEC, PM-SW, and REF Program
- Provide lightweight remote mount for M249, M240, & ACSW applications
- Target Wt: <150lbs with weapon/ammo
- Compliments CROWS-type system
- Elevation Range: +45º to -15º
- 2-Axis Stab; 360º continuous rotation
- Live- Fire testing underway
- ARDEC & PM working path ahead for evaluations in Iraq

ARDEC Tech Base Investments

Some examples w/ Joint Service linkage

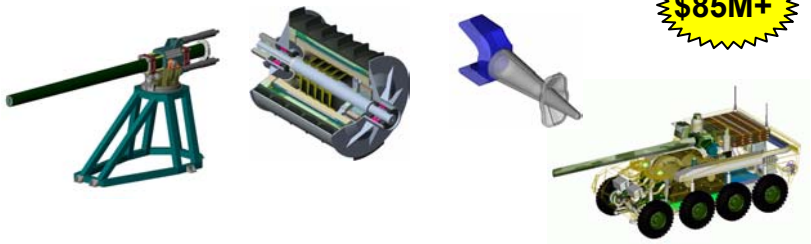
LtWt 81mm Dismounted Mortar (FY04-06)

$7M

- 40-50% weight reduction
- Joint Army/USMC (ONR) funded
  - $10M (N)
- Transition to SDD FY06

Electromagnetic Gun (FY04-06+)

$85M+



- Subsystem Technology Maturation
- Broad weapon mission applications across Services
- Army/Navy collaboration

USMC Interest expressed

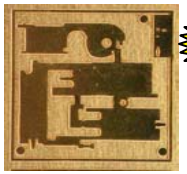
Micro Electro Mechanical Systems (FY00-07) (MEMS)

Inertial Measurement Unit

$110M

- Common Guidance across munition/missile
- Includes Mantech $'s
- Army Lead; Joint with Navy & Air Force

Safe & Arm Fuzing

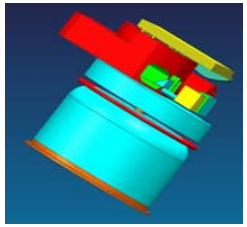


$22M

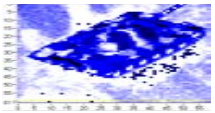
- Gov't high-G design
- Applications to small - large caliber applications
- Includes Mantech $'s

Common Smart Submunition (FY04-09)

$60M



Combined Effects Explosively Formed Penetrator (EFP)



LADAR

- Next generation smart submunition
- High kill probability against threat spectrum incl APS
- Application across munitions/missiles(≥105mm) & UAVs
- Supports Air Force "Area Dominance" via MOA

Navy Interest expressed

$xM = Army Funding

Special Weapon Observation Reconnaissance Direct-Action System (SWORDS)

SWORDS

Program Description

- **Objective:** Demonstrate integration of available firepower options on small, low-cost, remotely operated weapon system at extended ranges
- **Warfighter Payoffs:**
  - Remotely Operated Recon & Security Asset
  - Remote sniper capability
  - Increased weapons accuracy/control
- **Design Approach:**
  - Maximize use of proven components
  - Enable easy integration of existing fielded small arms
  - Early User feedback on design
  - Early Safety Confirmation testing
- **Joint ARDEC/OSD funding (~$2M)**
- **Transitions to Joint Project Office for Robotic Systems**

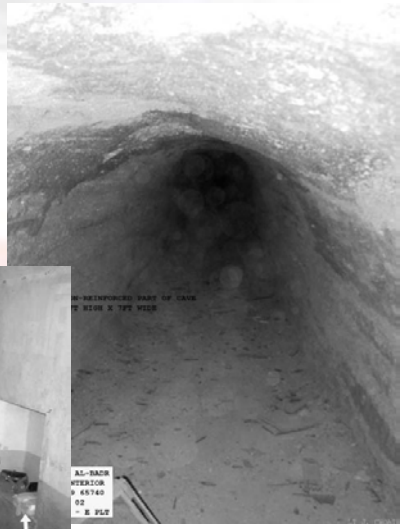
Foster-Miller
A QinetiQ Company

precision remotes

Helps keeps soldiers out of harms way

Background

- Project initiated from a deployed EOD Unit's desire to clear cave entrances of potential threats (i.e. IEDs, enemy combatants)
- Two (2) concept demonstrators completed in ~1 month+
  - ARDEC EOD NCO "boot strap project"
  - Capitalized on existing EOD TALON Robot
    - Reinforced EOD robotic arm
  - Maximized use of existing armaments and/or ammo



Live Fire - Early Concepts

40mm Grenade Launcher

Mobile 40mm Grenade Launcher Prototype Tests

sponsored by TACOM

Range supported by ARDEC - Picatinny

testing perfromed by Foster-Miller

Live Fire - Early Concepts

M202 66mm Rocket Launcher

Early User Demonstrations

- Army's Stryker Brigade
  - FY03 at Ft. Lewis; Proof of Concept
  - FY04 in Kuwait; User evaluation
  - Yielded evolution of SWORDS configuration integrating small arms
- SOCOM in FY03/04
- VERY POSITIVE feedback on utility of concept

Early User Feedback Key to Validate Design Principles

System Description
Latest Configuration

- Integrates TRAP Mount on TALON
  - Accurate weapon pointing independent of chassis
  - ± 35° Az and ± 22.5° El
  - Integrates M249, M240B, M16, & 0.50 Cal Sniper Rifle w/o weapon modifications
- Unmanned RF control to 1KM (line-of-sight) via Operators Control Unit (OCU) for:
  - Mobility
  - Camera display options (view up to four images)
  - Weapon arm/safe/firing
- Five cameras/sights
  - Day/ Night drive cameras
  - Pan & tilt camera (situational awareness)
  - M145 w/Unitary Night Sight (Gen 3) for targeting
- Combat weight 180-190 lbs (w/o OCU)
- 3-6hr Lithium Ion Battery Life

Live Fire & Mobility Demo

(segment from History Channel's "Mail Call")

Safety Confirmation Test Program

- Initiated early in development to support Urgent Material Release and flush out any anomalies
  - Two test iterations: Jun 04 & Jan 05
  - Included 100hrs reliability testing
- Testing currently halted; Program addressing test findings
- What's been demonstrated:
  - Stable firing platform for accurate single shot & burst performance
  - Better line-of-sight range command control performance than expected
  - Excellent video performance from cameras/sight upwards to 1km
- Remaining areas to be validated:
  - Weapon safety during communications loss/interruption & operator notification
  - Fire on the move disable feature
  - Lithium battery performance parameter refinement (controls) for safe operation, charging, and discharging
  - Sunlight readable LEDs on OCU

Design modifications required for operation in theater of war

Path Ahead

- Return to Safety Confirmation Testing (~Jun 05)
- Continue demonstration of capabilities to Users
- Continue preparation activities for Urgent Material Release
- Plan and seek resources for follow-on spiral improvements

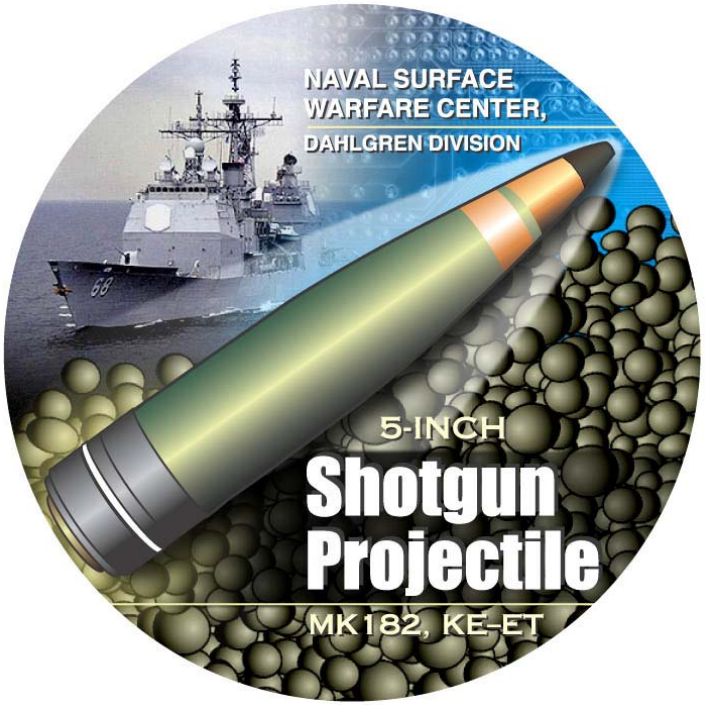
In Summary....ARDEC/Picatinny...

- **Established “Center of Mass” for Armament Systems and Munitions for Joint Services**
- **Proven track record of rapid transition of technology to the field**
- **Modernizing R&D facilities maintaining world-class capabilities**
- **Developing new concepts/technologies to enhance warfighter capabilities**
- **Demonstrating future warfighting capabilities today!**

ARDEC/Picatinny…….

Products, people, and processes enabling our ultimate customer, the soldier, to “take care of business” throughout the spectrum of conflict!

Lessons Learned From the Development of the U.S. Navy 5-Inch Ship Self-Defense Projectiles



Luke Steelman
Naval Surface Warfare Center Dahlgren Division, Code G33
Sanford.Steelman@navy.mil
(540) 653-4984 DSN: 249-4984

Agenda

- Ship Self-Defense
- Program Drivers
- Two Projectile Solution
- Program Overview
- Program Timeline
- Projectile Bodies
- Fuzing
- IM & Safety
- GWS Upgrades & Training
- Effectiveness
- What Is Next?

Sponsored By:

NAVSEA WARFARE CENTERS DAHLGREN

NAVSEA WARFARE CENTERS CRANE

NAVSEA WARFARE CENTERS PORT HUENEME

NAVSEA LOUISVILLE Gun Weapon Systems Station

GENERAL DYNAMICS Ordnance and Tactical Systems

BAE SYSTEMS

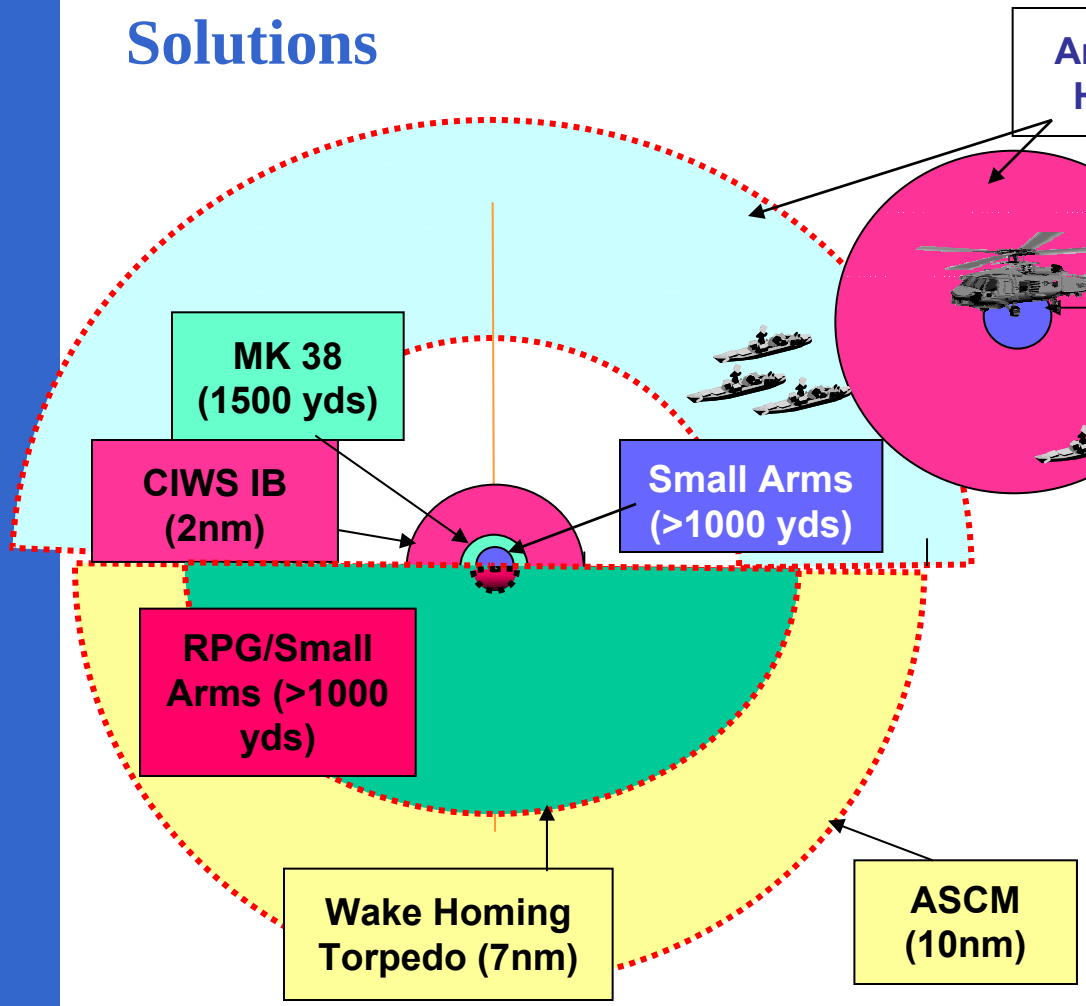
L3 communications BT Fuze Products

HEVI-SHOT

EDO corporation GLOBAL TECHNOLOGY REACH

Ship Self-Defense

Solutions



Threats

- Fast Attack Craft
- Fast Inshore Attack Craft
- Torpedo Boats

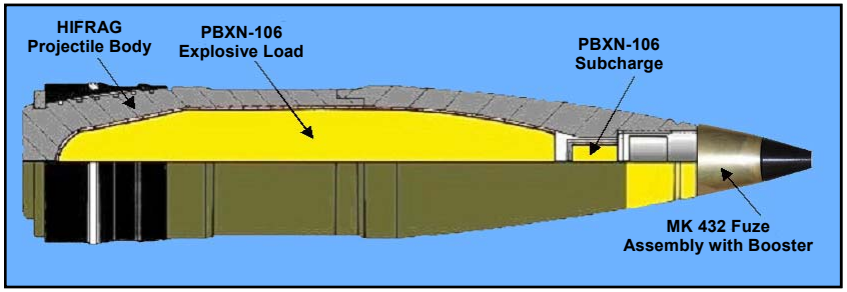
Threats

Program Drivers

- Immediate solution needed
  - Threat realized during USS COLE Incident
- Projectile assets available
  - HIFRAG projectiles in inventory
  - Cargo projectile bodies and fuzes in inventory with no qualified payload
- Field in minimal time
  - Minimal impact to GWS

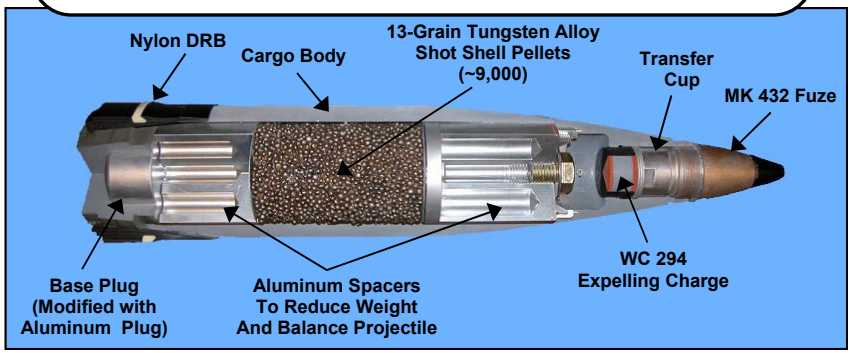
Two Projectile Solution

MK 179 HE-ET (High Explosive)



- Existing HIFRAG projectile retrofitted with MK 432 Electronic Time Fuze
- Implementation optimized for anti-personnel engagements
- Most effective at longer engagement ranges

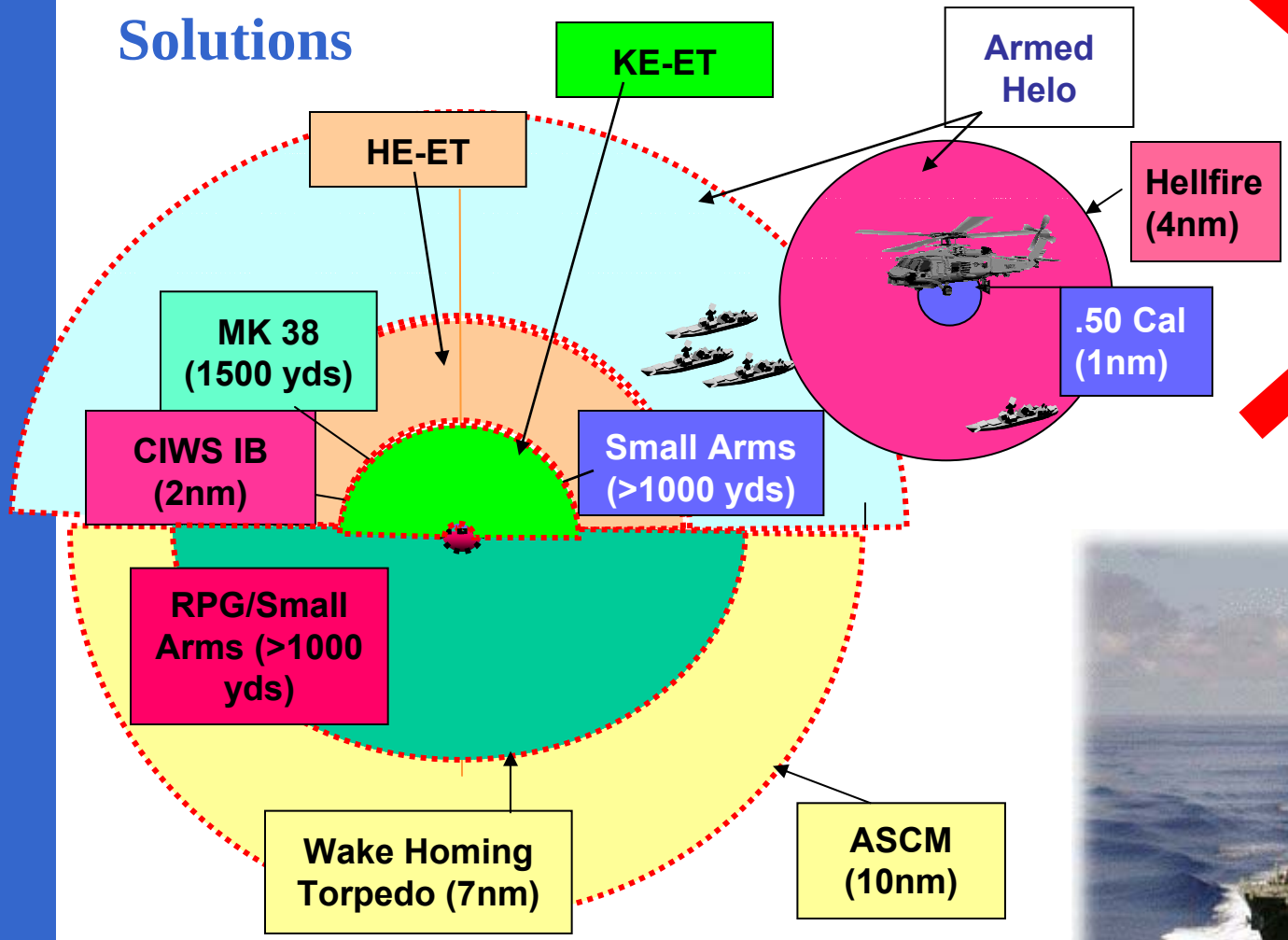
MK 182 KE-ET (Kinetic Energy) "BB Round"



- New payload for existing Cargo Projectiles
  - COTS tungsten pellets
- Same MK 432 ET Fuze
- Optimized for anti-personnel engagements
- Most effective at shorter engagement ranges

Ship Self-Defense w/HE-ET & KE-ET

Solutions



~~Threats~~

- ~~Fast Attack Craft~~
- ~~Fast Inshore Attack Craft~~
- ~~Torpedo Boats~~

Threats

Program Overview

- Product Improvement Program (PIP) initiated Fall ’02 as a demo in support of N76’s Hip-Pocket Task Force
- One time procurement of 8,000 rounds
  - 4,000 of each configuration
  - Rounds produced and in inventory
  - Reserved for CGs and DDGs that have received GWS upgrades and are deploying
- 1st CG & DDG deployed with HE-ET & KE-ET 2nd Qtr 2005

Program Timeline

- First Land Based Demonstration – Sep 02
- Safety Review Board Concurrance with Projectiles – Sep 03
  - Demo to WSESRB Concur with IOC = 54 weeks
- All projectiles loaded & in inventory – Feb 04
- Shipboard Test Series – Fall 03 to Fall 04 (4 events)
  - USS LAKE CHAMPLAIN
  - USS VELLA GULF
  - USS ROSS
  - USS PINCKNEY
- Ship Upgrades – Begun in Fall 04 (ongoing)
- Crew Training – Begun in Fall 04 (ongoing)
- Initial Operational Capability (on Deployers) – Mar 05

Fuzing

- HE-ET & KE-ET effectiveness dramatically enhanced by fuze performance
  - Precision timing – 10 msec setting increments
  - Timing Adjusted by Fire Control System for optimum burst location relative to target

MK 432 Mod 0 Electronic Time Fuze

Projectile Bodies

- Cargo projectile bodies were available in inventory
  - Fully qualified projectile without qualified payload
  - Flexible design allowed for easy integration of COTS tungsten pellets
  - Other needed parts designed to be manufactured by any machine shop
- HIFRAG projectiles in inventory
  - Chosen over available MK 64 projectiles due to lethality against personnel targets
  - Required only replacement of fuze, no other modifications

Cargo Projectile

IM & Safety

- KE-ET & HE-ET qualification included full Safety and IM test series
  - Safety Program
    - MIL-STD-2105 testing
    - Full WSESRB Approval
  - IM Program
    - Scores based on IM tests and analogy
    - Both projectiles passed with waiver
    - KE-ET most IM compliant 5-Inch projectile
      - Improvements needed to pass Fast & Slow Cookoff

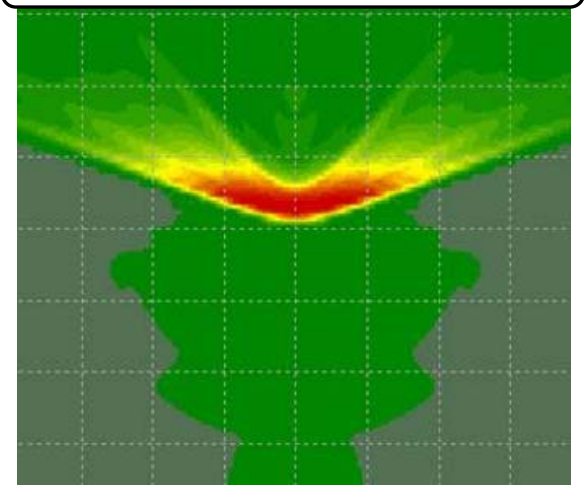
GWS Upgrades & Training

- GWS Upgrades
  - Fire Control Software
  - Optimized Ballistics
  - Fuze Setter
  - GWS upgrades in progress for all CG and DDG class ships
- Training
  - Short Term (FY05) – Program Office
  - Long Term (FY06+) – Afloat Training Group (ATG)

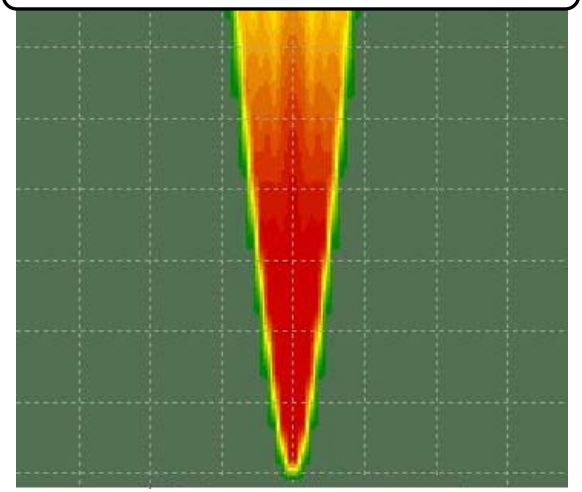
Effectiveness

- HE-ET very effective at longer ranges and against maneuvering targets
  - Wide fragmentation pattern still hits turning/maneuvering targets
  - Large number of high-speed fragments very lethal
- KE-ET very effective at shorter ranges and against straight line targets
  - Forward fragment blast very effective at low angles of fall
  - Long pattern compensates for range errors inherent to gun engagements
  - High density COTS pellets offer better penetration than steel fragments

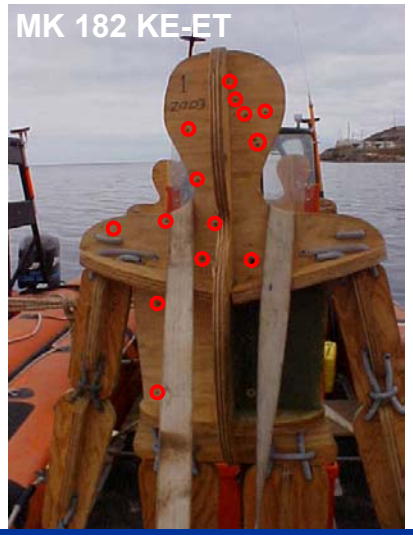
MK 179 HE-ET @ 5kyds



MK 182 KE-ET @ 3kyds



MK 179 HE-ET & MK 182 KE-ET Shipboard Test Results



Fragmentation and Lethality Models Validated within 10% by Land Based and Shipboard Testing

Potential Upgrades

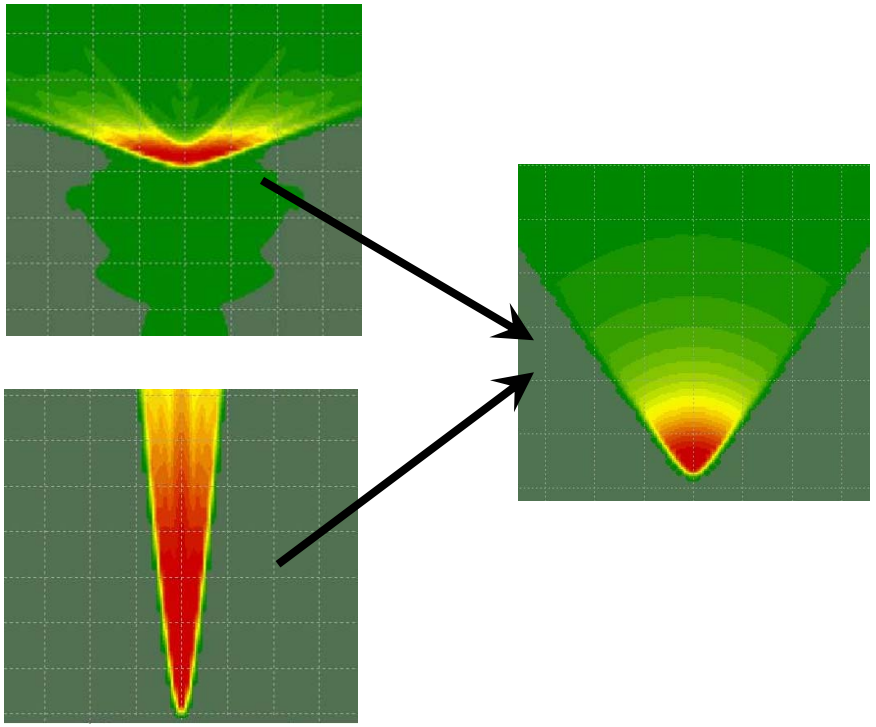
- HE-ET Potential Upgrades
  - Change shape of HE charge
  - Change fragmentation properties of projectile body
  - Incorporate high-density pre-formed fragments
- KE-ET Potential Upgrades
  - Forward expel payload for increased kinetic energy on target
    - Phase II SBIR Contract, Veritay Technology, Inc.
  - Upgrade payload to larger size/higher density pellets
  - Enhance radial pellet dispersion with mechanism or energetics
- Fuzing Upgrades
  - Multi-mode fuze would change from ET to Surface Proximity Mode at optimal range to extend maximum range
    - MK 419 Multi-Function Fuze (MFF)
    - EX 437 Multi-Option Fuze (MOFN)

What Is Next?

- NAVSEA approved a FY05 study of various concepts to find “Best Value” solution
  - Study report due for completion by end of FY05
  - Follow-on action to be determined by study findings
- Best Value
  - The best balance of the following factors to meet the program objective
    - Cost
    - Performance
    - Risk
    - Schedule
- Mission Kill
  - Firepower
  - Mobility
  - Personnel

What Is Next?

- Advanced Shotgun Projectile
  - One optimized projectile replacement for both KE-ET and HE-ET
  - Increases effectiveness from Anti-Personnel to Mission Kill
  - Address IM improvements



Ship Self-Defense Projectiles

- Quick turn around solution to immediate threat
- Successful qualification and IOC of two new projectiles
- Projectiles produced and in inventory
- Ship upgrades and crew training ongoing
- First ships on deployment with HE-ET & KE-ET
- Future upgrades being investigated in Advanced Shotgun Projectile Study

"Fully Field the 5" gun BB round to enhance capability against the small boat threat." -- CNO Guidance for 2005

XM395 Precision Guided Mortar Munition (120mm PGMM)

Responsive, Standoff Precision Lethality for Highly Deployable and Mobile Forces

"Translating Lessons Learned into Systems Requirements"
40th Annual Armament Systems: Guns-Ammunition-Rockets-Missiles Conference & Exhibition
April 25-28 , 2005

Presented By: James Terhune and Anthony Pezzano
OPEO Ammunition/OPM CAS/ OPM Mortars

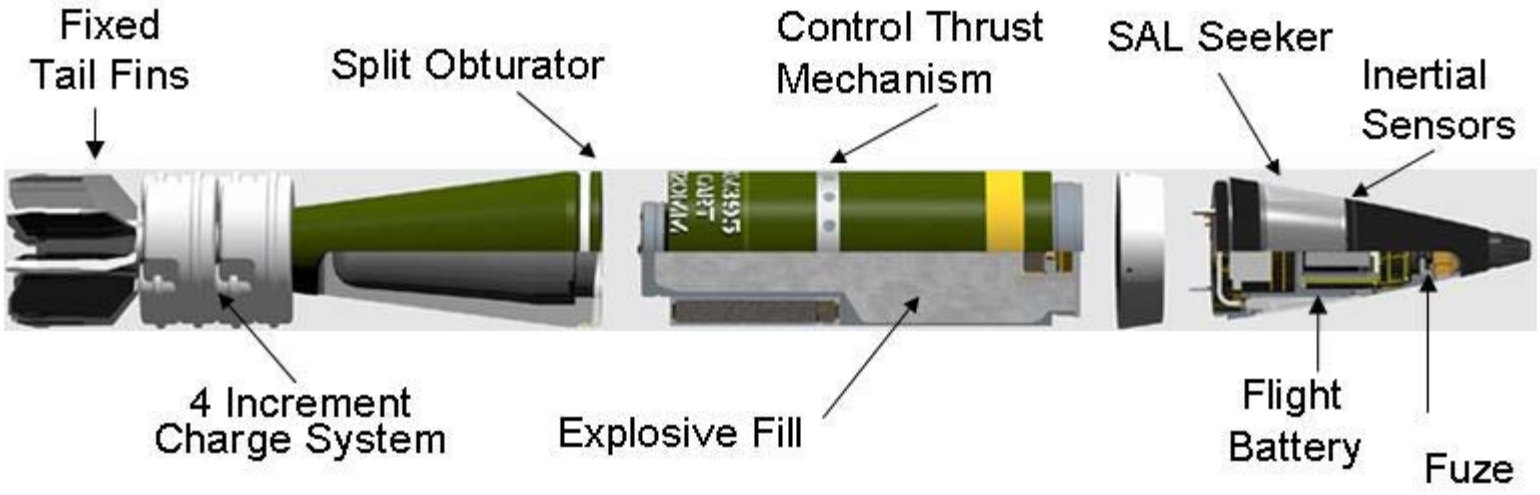
Task

Present a Summary of the Product Manager's Approach to PGMM Training

Purpose

Develop Systems Approach for PGMM Training Concept Utilizing Six Sigma Principles and Processes

PGMM Description



System Requirements (Key Performance Parameters):

Increment I

Lethality: Incapacitate protected personnel, in two rounds or less, within:

- Earth and timber bunkers
- Brick over block masonry structures
- Stationary lightly armored vehicles

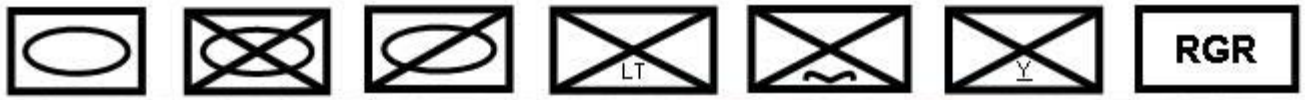
Maximum Range:

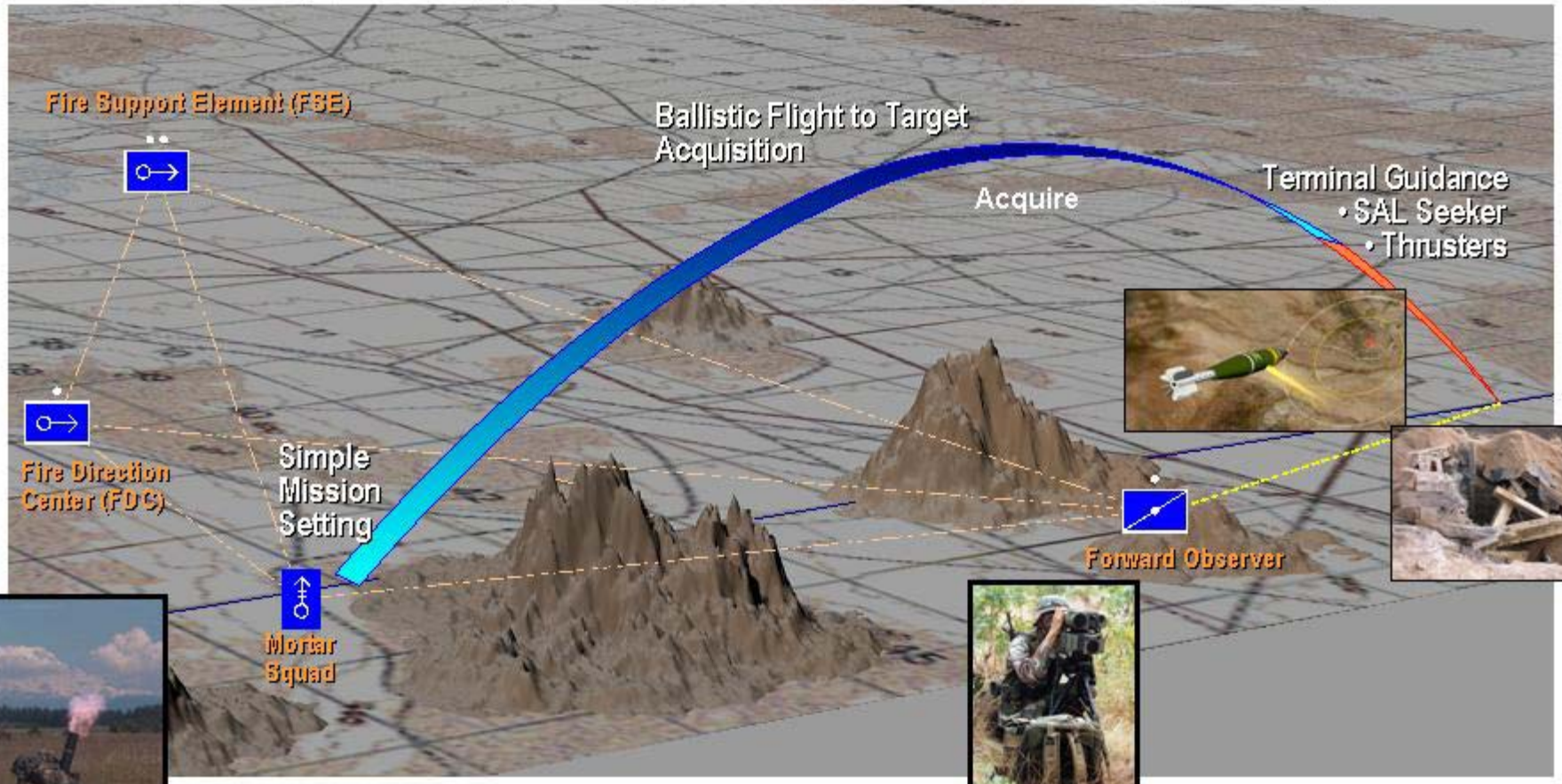
- Current Force: 7.2km (Threshold), 10km (Objective)
- Future Combat System (FCS) Mortar: 8km (T), 10km (O)

Compatibility:

- 120mm Battalion Mortar System
- Stryker - Mortar Carrier
- FCS Non-Line of Sight (NLOS) Mortar
- Current / Future Laser Designators & Fire Control Systems

PGMM Operations





Leverages Existing Fire Support Systems
Reduces Collateral Damage

Masonry Structures
Earth and Timber Bunkers
Light Armor Vehicles

Precision Munitions Increase Warfighter Effectiveness

Mortar Infrastructure In Place

Joint Service Forward Observers & Designators

Mortar Fire Control System

- 120mm Mortars in current infrastructure
  - 120mm Mortar Platforms: M121 (carrier-mounted), M120 (towed), Stryker - Mortar Carrier
  - 120mm Mortar Munitions: HE, Smoke, Illumination (Visible & Infrared)
- Light-weight Laser Designator Range Finder (LLDR)
- Fire Control / Command & Control Links
  - Mortar Fire Control System (MFCS)
  - Advanced Field Artillery Tactical Data System (AFATDS)

Towed 120mm (Ground Mounted)

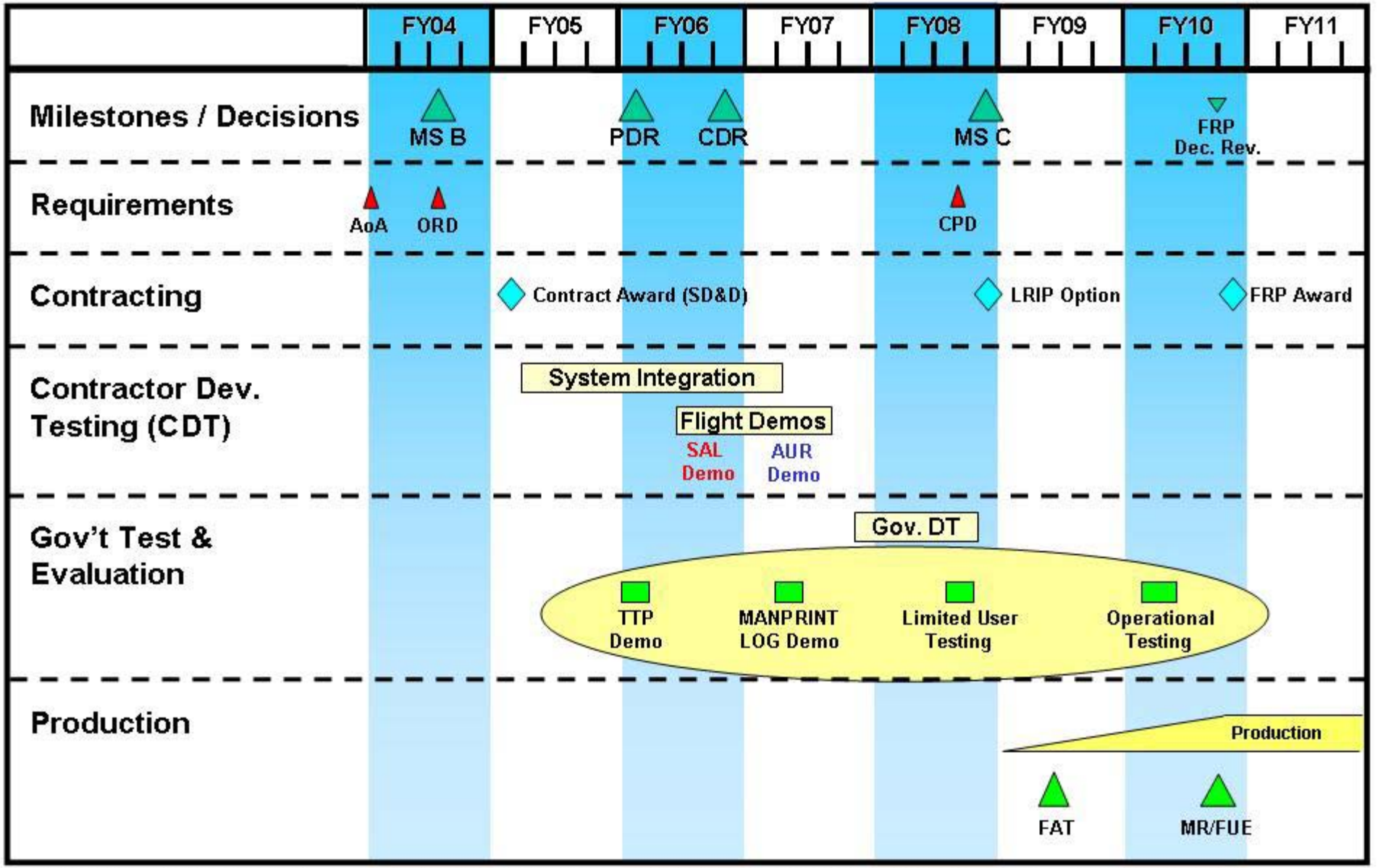
M1064

Vehicle Mounted 120mm Stryker MC

NLOS-Mortar (future)

PGMM
An Integral Part of Modern and Future Battalion Indirect Fire

Baseline PGMM (Increment I) Program Schedule



AoA: Analysis of Alternatives
FRP: Full Rate Production

TTP: Tactics Techniques Proc.
AUR: All Up Round

Gov. DT: Government Development Testing
FAT: First Article Test

MR: Material Release
FUE: First Unit Equipped

Problem Statement

- Reduced Combat Effectiveness without Adequate Training Program
- No Affordable or Practical PGMM Training System is Available
    - Current Options
        - Firing Tactical Laser Guided PGMM (Hundreds of Rounds/Year x $10K/Round)
        - No Training (Not an Option)
        - Manual Process @ Training Center (not representative of Tactical)

Project Goals

- Develop an integrated plan for PGMM Training Concepts that can:
  - Effectively Train the Mortar Crew
    - Preparation, drop firing, and misfiring procedures
  - Training of Forward Observer to Adequately Designate Targets within the PGMM Firing Mission Timelines
  - Communication Links between FO, Battalion FSE, FDC and Mortar Crew
  - Achieve a 50% minimum overall Cost Avoidance through Reduced Tactical PGMM Firing
    - Cost effective training concept alternatives.

NOTES: FSE: Fire Support Element FDC: Fire Direction Center FO: Forward Observer

PGMM Training Q$SR

Type		
		Engineering
		Production
		Business
	x	Management

Project Summary:

Develop an integrated plan for PGMM Training Concepts that can:

- **Effectively Train the Mortar Crew**
  - **Preparation, drop firing, and misfiring procedures**
- **Train Forward Observer to Adequately Designate Targets within the PGMM Firing Mission Timelines**
- **Identify Communication Links**
- **Achieve a 50% minimum overall Cost Avoidance through Reduced Tactical PGMM Firing.**

Quality or Customer Satisfaction	*Co$t*
Provide the Warfighter with a viable low cost training solution to achieve indirect fire precision strike capability.	**Potential savings $10.24M/year of Training (10 year product life cycle can save over $100M in training costs)**
Project Successfully laid out Approach, Methodology and Plan. (Follow-on Project recommended to Implement Training Concept into Program SDD)	**FMEA evidenced medium risk areas.** FO Trainer; Virtual Simulator **QFD identified Training Concept leverage points to maintain affordable approach.**
Schedule	*Risk*

PGMM Training Implementation

Implementing PGMM Training

- **New Equipment Training (NET)**
  - Update documents to include PGMM and operating Tactics, Techniques and Procedures.
  - Develop physical mock up of PGMM for handling, programming, and visual reference.
  - Text / Video Course instruction training material.

- **Institutional Training**
  - Develop classroom training.
  - Integrate CFFT / Mortars / MFCS / PGMM / Laser Designation for classroom training.

- **Virtual Training**
  - Understand / Develop Tactics, Techniques & Procedures (TTPs).
  - Integrate CFFT / Mortars / MFCS / PGMM / Laser Designation for virtual training.
  - Integrate PGMM Trainer with MFCS Gun & FDC training aids and devices.
  - Develop Models and Simulations as part of Virtual Training resources to support Live Training.
  - Virtually train Gunner, FDC, and Forward Observer in a closed loop system, for collective unit training.

- **Collective (Live and Combined Arms)**
  - Develop Embedded Training Instrumentation (MFCS).
  - Provide a PGMM training capability at the Combat Training Center (CTC) .

Who We Will Be Training

- Fire Direction Specialist (MOS 13F)
- Indirect Fire Infantryman (MOS 11C)
- Ammunition Specialist (MOS 55B)
- Fire Direction Center (FDC) Personnel
- EOD

Mortar Mission Training Requirements

- Operate in Centralized or Decentralized C3 Modes
- Centralized: Through Battalion Fire Support Element
- Decentralized: Sensor to FDC and/or Gun

PGMM Call for Fire

Forward Observer

Company FIST[1]

Battalion FSO[2]

Mortar FDC[3]

Mortar Squad

1 Target Identified

8 Shot Out

9 Lase Target

10 End of Mission, BDA[4]

Advanced Field Artillery Tactical Data System (AFATDS)

Mortar Fire Control System (MFCS)

2 Call For Fire

M95 MFCS

6 Shot Over

7 Lase Target

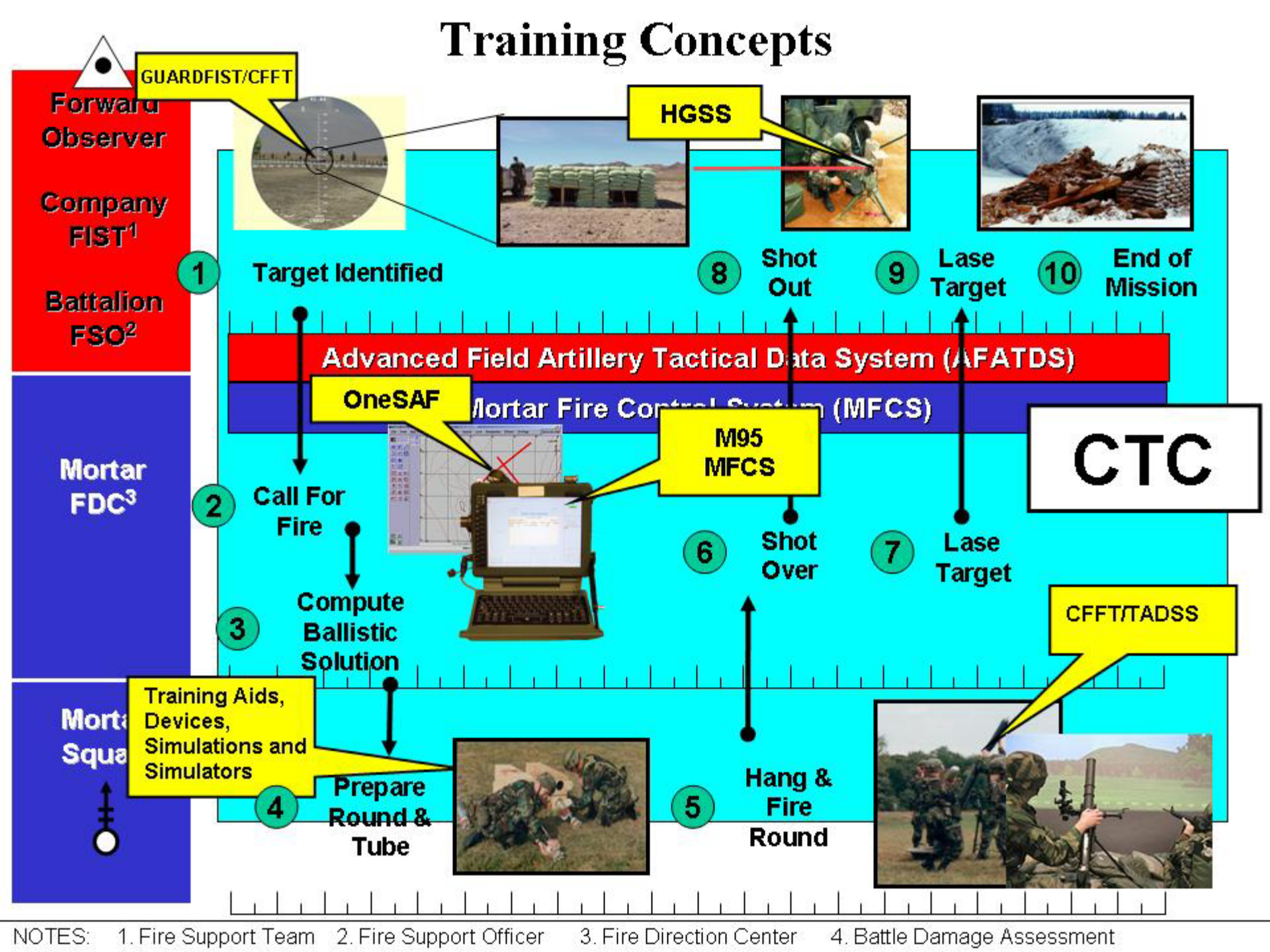
3 Compute Ballistic Solution

4 Prepare Round & Tube

5 Hang & Fire Round

NOTES: 1. Fire Support Team 2. Fire Support Officer 3. Fire Direction Center 4. Battle Damage Assessment

Training Concepts



NOTES: 1. Fire Support Team 2. Fire Support Officer 3. Fire Direction Center 4. Battle Damage Assessment

Summary

- US Army investing in Precision Munitions for Close Combat (Mortar Systems)
  - Requirements are Approved
  - Program is Fully Funded, PGMM SDD Awarded 01Dec04
- Result will be Leap Ahead Precision Effects Capabilities for the Maneuver Commander
- Training is key to PGMM Affordability and Performance
- Collective/Combined Arms Training Requirements are being defined

6th Annual Mortars Conference October 19-21, 2005
Headquarters Plaza Hotel, Morristown NJ

www.NDIA.org **w4.pica.army.mil/pmmortars**

Design for Manufacturing & Assembly (DFMA)

Steve Watts

Production Engineering Division
Engineering Directorate
Aviation & Missile Research, Development, & Engineering Center
Research, Development, & Engineering Command
Redstone Arsenal, AL

28 Apr 05

Introduction

- In state-of-the-art weapon system development, emphasis is largely placed on designing to meet technical performance
- However, the manufacturing processes and cost associated with the design must also be addressed for overall program success
- Limited resources within DoD make designing for cost effectiveness even more imperative
- Numerous studies show that the most effective time to implement cost saving changes is early in the product design cycle
- Widely accepted commercial Systems Engineering standards consider “Manufacturing Processes” as one of the basic building blocks of a system
- The “Brick Wall” syndrome still exists today

DFMA Workshops are an excellent tool to break down the “Brick Wall”

What is DFMA?

- DFMA is a proactive and concurrent design process that allows for early consideration of manufacturing aspects

- The purpose is to generate an environment where a cross-functional team works together to optimize the design for cost effective manufacturing

Benefits

Tangible

- Shortened Development Time
- Reduced Development Costs
- Enhances a smooth transition to production
- Reduced parts count
- Simplified assembly processes
- Improved Quality (fewer opportunities for mistakes)
- Reduced manufacturing costs (thereby reducing AUPC and Life Cycle costs)

Intangible

- Improved communication within entire design team
- Promotes teamwork
- Increases Organizational ownership

DFMA Principles

1. Minimize the number of parts
2. Minimize the number of fasteners
3. Standardize
4. Avoid difficult components
5. Use modular subassemblies
6. Use multifunctional parts
7. Minimize reorientation
8. Use self-locating features
9. Avoid special tooling/test equipment
10. Provide accessibility
11. Minimize operations & process steps

Reduce, Eliminate, Combine, Minimize, Standardize, Productionize …

When to Implement

- Could conceivably conduct workshops during Concept phase
  - Focus on broad, wholesale design changes
  - Opportunity to consider manufacturing impacts of one technology vs. another
  - Be careful not to fine tune this design (could become obsolete)

- Most effective time is during Development Phase (prior to PDR)
  - Coincides with the time period where trade study activity is most active
  - Engineering testing will occur after PDR, which will prove-out changes
  - Technology has been selected, but design is flexible
  - Time remains in development schedule to incorporate significant cost saving changes

- Workshops during Development Phase after the PDR, but prior to the CDR
  - Design is becoming more fixed, but opportunities for cost savings still exist
  - Focus on fine tuning aspects of the design that successfully completed the PDR
  - Be careful not to implement major changes (no time to incorporate)

Key Points / Lessons Learned

- Must have multi-functional team
  - Concurrent Engineering
  - Include disciplines such as systems engineering, design, manufacturing, quality, test, etc (even manufacturing floor personnel)
- Use an independent facilitator
  - No ownership in design and can keep flow of workshop moving
- Conduct multiple workshops
  - break system down into manageable pieces
- Prep work
  - Overview description of hardware
  - Preliminary manufacturing assembly flows
  - Have some type of cost baseline to perform trade studies
- Utilize Brainstorming techniques
  - Facilitize free flow of ideas (check rank at the door)
  - Don’t be resistant to changes
  - Don’t get bogged down by trying to solve the details
- Follow-up on ideas after workshop has ended

DFMA Workshop Procedure

During the Workshop

(Normally scheduled for 1-2 days)

- Training
  - Educate team on workshop procedures and DFMA principles
  - Get people thinking in terms of producibility
- Baseline the current design
  - Team needs to understand where we are
  - Provide an overview description of hardware & assembly procedures
- Brainstorming Session
  - This is where the true benefit of the DFMA workshop is realized
  - Utilize Brainstorming techniques
- Categorize Ideas
  - What is risk to implement (technical & manufacturing)
  - Cost savings potential (Rough estimate - large, small, or insignificant)
  - Is there a cost to implement (development dollars, tooling, test equipment, etc)

DFMA Workshop Procedure

(Continued)

After the Workshop

- Detailed assessments and Implementation
  - Cull out brainstorming ideas that are too difficult, risky, or costly to implement
  - Focus on ideas that can truly benefit program
  - Incorporate results into Systems Engineering process
  - Perform detailed evaluations and/or trade studies
  - Identify candidates that can be implemented in current program
  - Identify candidates that can be implemented in other vehicles (Mantech, IRAD, Technology Insertion, etc)
- Quantify results
  - Document ideas that are carried forward
  - Document specific improvements
  - Identify cost savings (may be difficult in early development phases)

Examples

Program	Contractor	Results
Longbow (Transceiver CRP)	Lockheed Martin / BAE - Nashua	- Number of operations reduced 20% - Assembly hrs/unit reduced 20% - Floor space reduced 20% - Increased production from 52 to 220 units/mo
Longbow (Counteractive Protection System)	Remec / BDI	- Re-layout of electronics for accessibility - Number of chips & carriers reduced - Implemented auto assembly procedures - Combined parts
APKWS (Guidance Section)	BAE - Nashua / BDI	- Eliminated inaccessible areas - Color coded parts (assembly aide) - Injection moldings vs. machined parts - Eliminated fasteners and screws - Combined parts - Implemented self-alignment features
NLOS-LS (Seeker)	Raytheon - Tucson	- Generated 63 separate candidates - Reduction of alignment steps - Semi auto alignment procedures - Yield improvements for subcomponents - Candidates still being evaluated

Summary

- Successful implementation of DFMA principles results in reduced costs
- DFMA workshops serve as a practical tool to incorporate Concurrent Engineering procedures
- DFMA is a proven design methodology that works for Government and Commercial Industry

The AMRDEC Production Engineering Division's objective is to incorporate DFMA workshop requirements in all Development Program Scopes of Work

References

- GAO-02-701 Best Practices, Jul 02, “Capturing Design and Manufacturing Knowledge Early Improves Acquisition Outcomes”
- Article: Defense AT&L Magazine, Nov-Dec 04 Edition, “Using DFMA to Meet APKWS Cost Goals”, http://www.dau.mil/pubs/damtoc.asp
- Raytheon Missile Systems – Tucson, AZ
  - Mr. Tom Quinn, Systems Product Development Engineer, Engineering Directorate, Thomas_R_Quinn@raytheon.com
- BAE Systems – Nashua, NH
  - Mr. Joe Tiano, Technical Operations Manager, Joseph.J.Tiano@baesystems.com
- Boothroyd Dewhurst, Inc.
  - Mr. Nick Dewhurst, Executive Vice President, ndewhurst@dfma.com
- U.S. Army
  - Mr. Steve Watts, Team Leader – Tactical Weapons Group, Production Engineering Division, Steve.Watts@amrdec.army.mil

EBV Explosives Environmental Company

Joplin, MO

Commercial Disposal of Explosive Wastes

EBV//EEC
EXPLOSIVES ENVIRONMENTAL COMPANY

Celebrating 10 Years of Explosives Waste Disposal Service

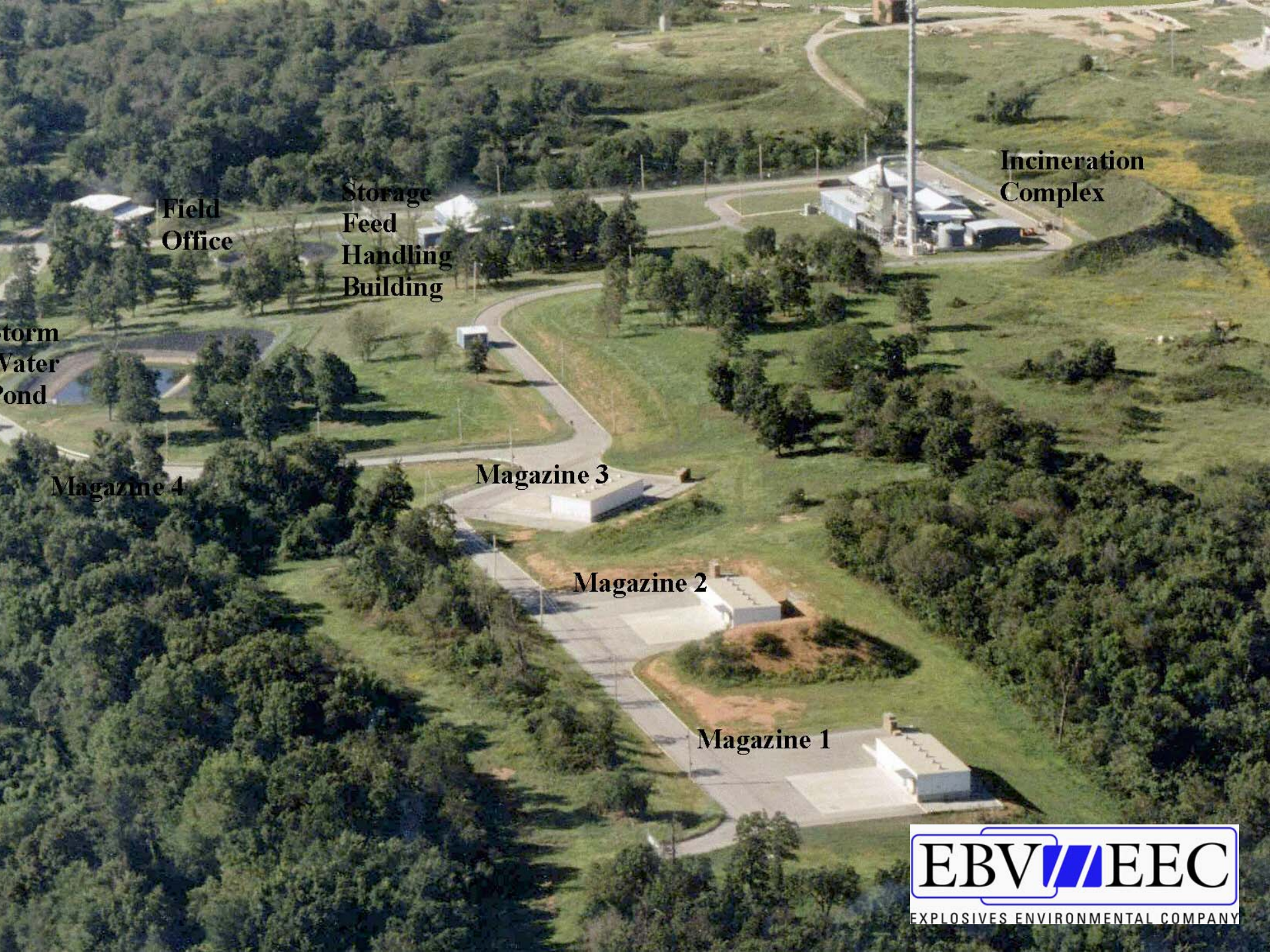
- EBV EEC's Joplin, MO, TSDF celebrates 10 years of operations (formerly ICIEEC)
- Only commercial HW incinerator in US specifically designed to incinerate explosive materials and devices
- Over 25 million lbs of explosive materials and devices incinerated over past 10 years

EBV//EEC
EXPLOSIVES ENVIRONMENTAL COMPANY

EBV EEC Facilities

- Demil Facilities
  - M483 ICM Projectile Download & Demil Process
  - Demil and Disassembly
  - Repackaging
- Incineration Equipment
  - Rotary Kiln Incinerator
  - Car Bottom Furnace
- 4 Storage Magazines

EBV//EEC
EXPLOSIVES ENVIRONMENTAL COMPANY


Incineration
Complex
Storage
Feed
Handling
Building
Field
Office
torm
Vater
Pond
Magazine 4
Magazine 3
Magazine 2
Magazine 1
EBV EEC
EXPLOSIVES ENVIRONMENTAL COMPANY

EBV EEC Demil Capabilities

- M483 ICM Projectile Disassembly
- Repackaging/Safing of Mortar Ctgs
- Delinking of Small Caliber Ammo
- Munitions Disassembly Equipment Development
- Munitions Sawing

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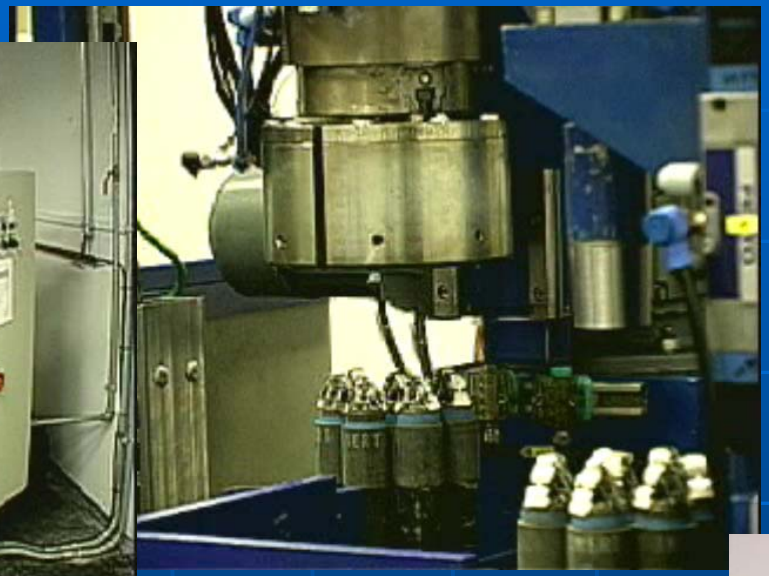
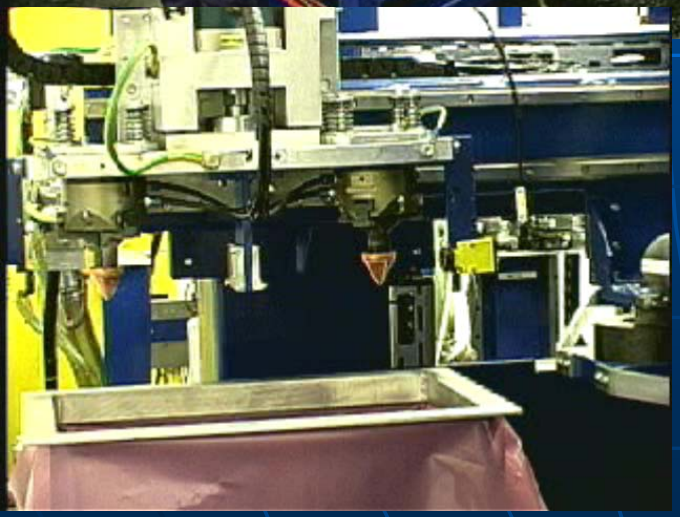
M483 ICM Projectile Demil





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Recyclable Materials Recovered from ICM Projectiles 93% R^3

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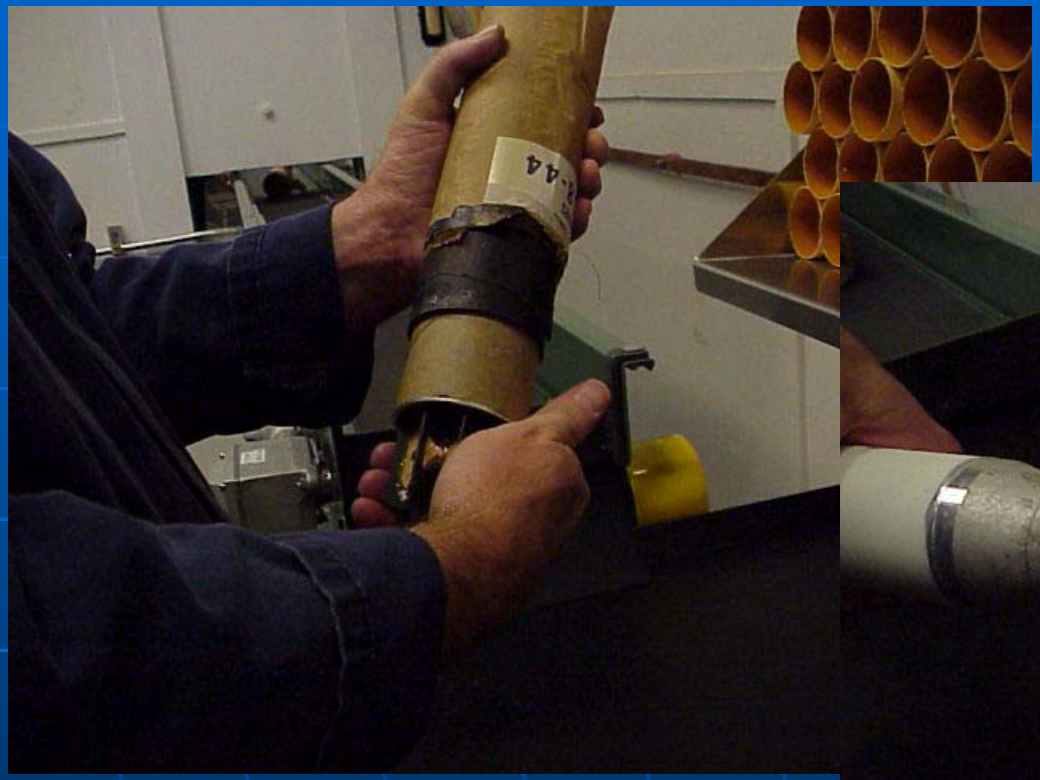
60mm Illuminating Ctg Demil



Unpack of 60mm Ctgs

Safing of Tail Fin Assembly
Prior to Incineration

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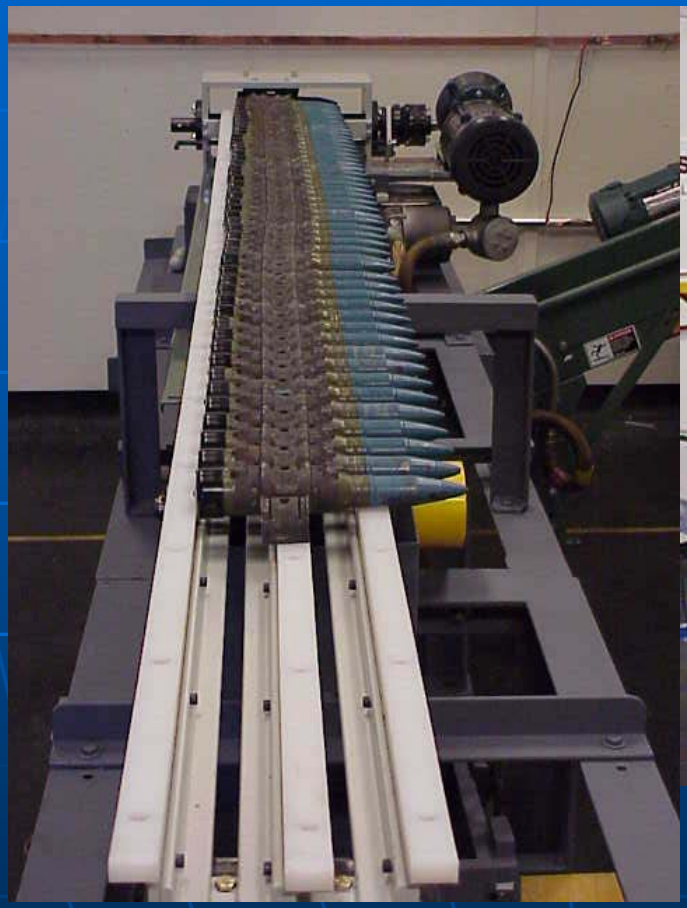
Small Caliber Ammo Delinking



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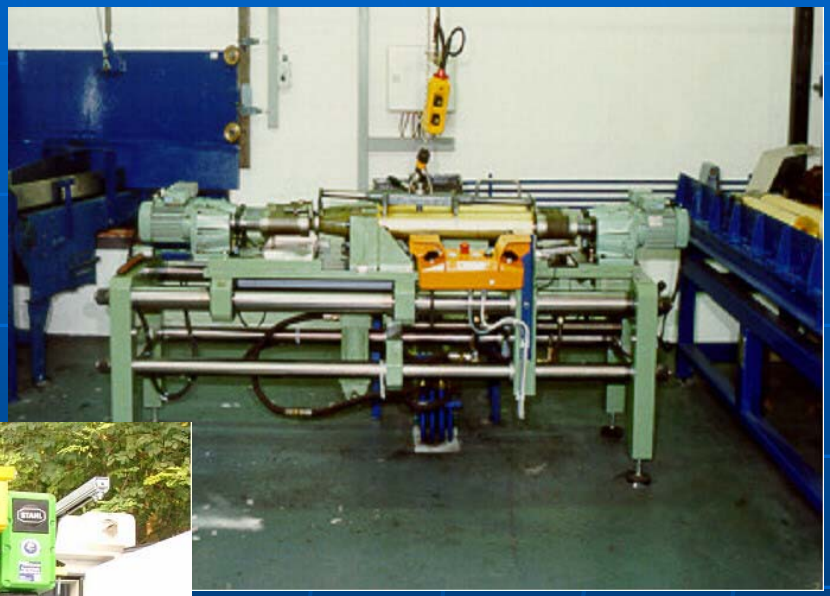
Disassembly Equipment Development



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Munitions Cutting

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Incineration Operations

- Rotary Kiln Incinerator
- Car Bottom Furnace
- Air Pollution Control System
- Recyclable Metal Recovery
- Types of Explosive Material Incinerated

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Rotary Kiln Incinerator

- 3 1/4” thick cast steel and 3’ diameter
- 6 section, no refractory
- Internal flight or helix to convey and separate waste
- Gas fired, countercurrent design
- 350 to 750 F
- Inside protective room

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Rotary Kiln Incinerator

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Car Bottom Furnace

- For incineration of explosives contaminated trash including PPE, packaging, rags, mops, etc.
- For flashing of explosives contaminated metal parts, drums, equipment, etc.
- Inside capacity 4’h x 5’w x 9’l

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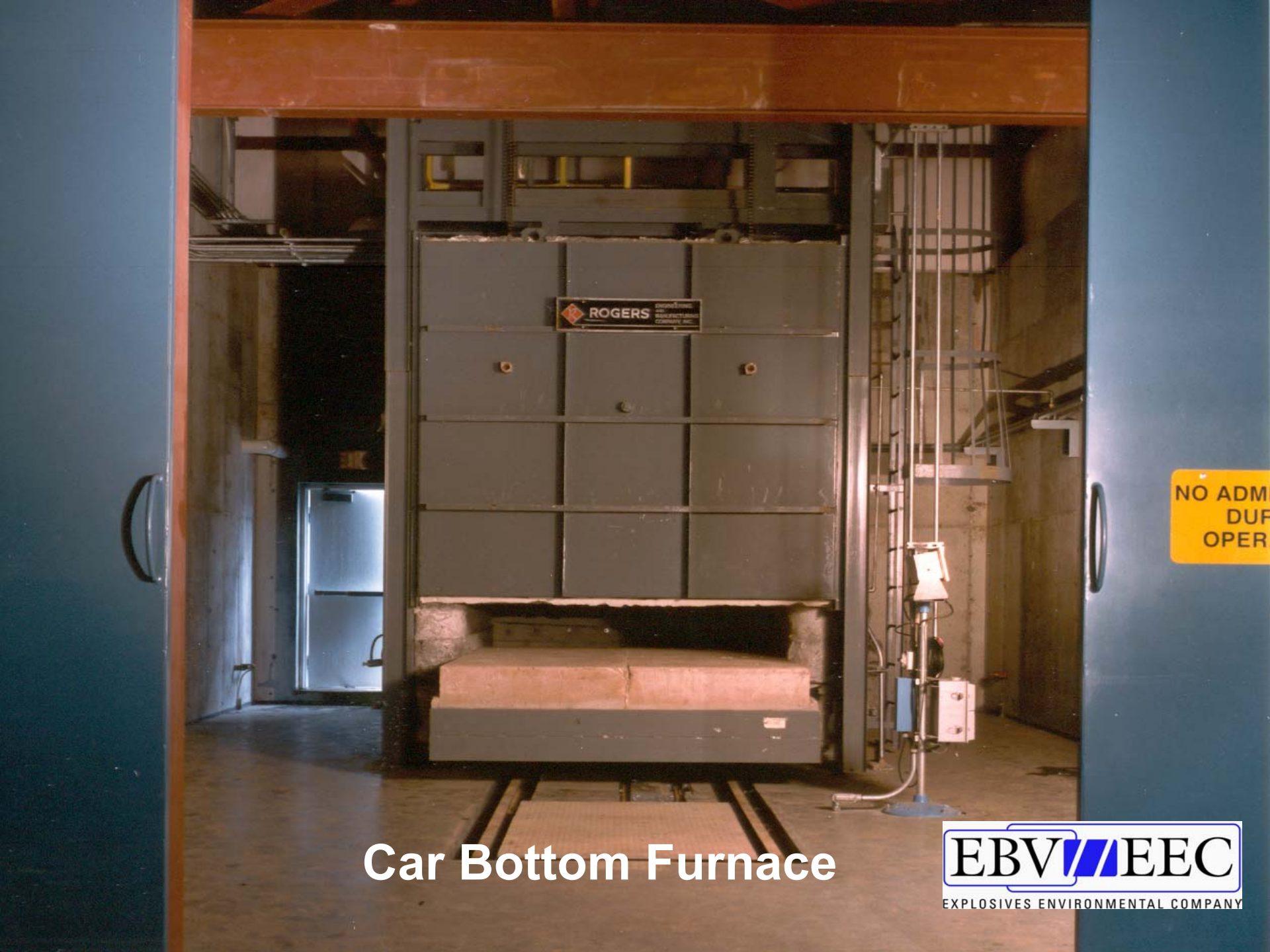

Car Bottom Furnace

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Features Of EBV EEC APCS

State-of-the-industry air pollution control system (APCS) meets all MACT standards including those for dioxins and chlorine

- Secondary Combustor provides >4 second residence time at 1900F to destroy organics
- Spray Dryer
  - Rapidly quenches exhaust gases
  - Neutralizes and removes acid gases, e.g., HCl through injection of soda ash in quench water – 99.6% chlorine removal
- Baghouses remove particulates

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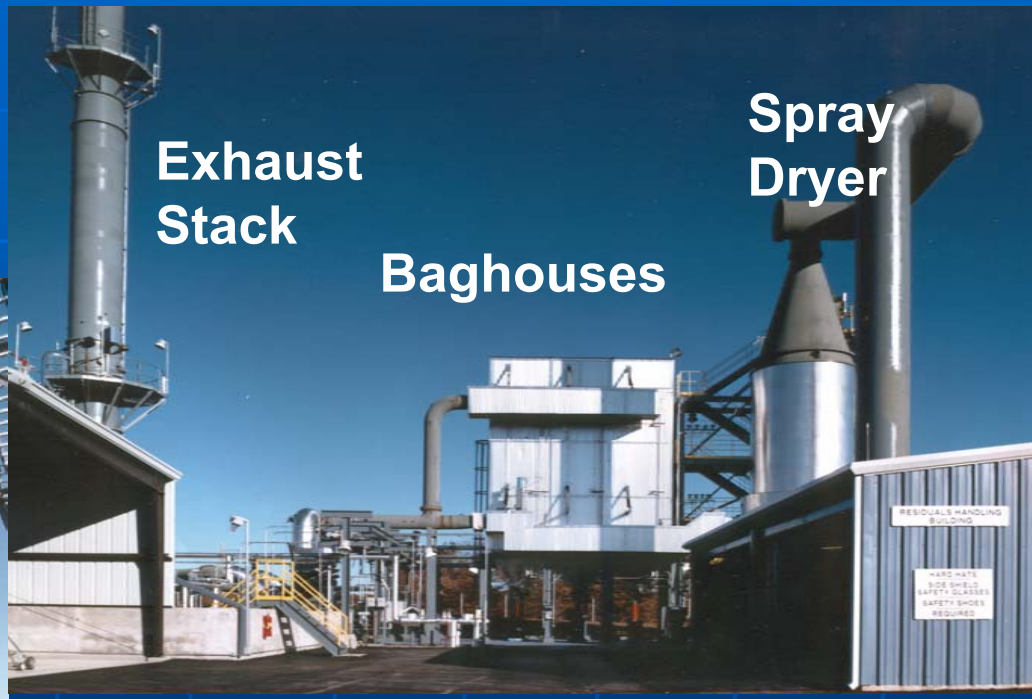
EBV EEC APCS



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Ash, Recycled Metals & Packaging Inspection

- All residual ash is disposed of in a Hazardous Waste Landfill
- All recyclable metals are 100% inspected
- DCMA spot checks all recyclable metal from government contracts prior to release to scrap metal dealer
- All packaging materials are 100% inspected and stamped by the inspector
- DCMA spot check all packaging from government contracts prior to recycling or disposal

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Recyclable Metal
Inspection Station
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Inspection of Recyclable Metals

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Types of Explosives Treated

- Military
  - Fuzes
  - Small Cal Ammo
  - Pyrotechnics
  - Bulk Explosives
  - Bulk Propellants
  - CAD/PAD Devices
  - Grenades & ICM
  - Smokes & Dyes
  - Riot Control Agents
- Commercial
  - Blasting Caps
  - Det Cord
  - Bulk Explosives
  - Bulk Propellants
  - Air Bag Materials
  - Oil Well Devices
  - Small Cal Ammo
  - Gas Generators

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Fuzes

Artillery and Bomb Fuzes

Over 3 million fuzes processed

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Small Caliber Ammunition

20mm thru 30mm Cartridges, Projectiles, and Primed Cases

Over 10 million rounds processed

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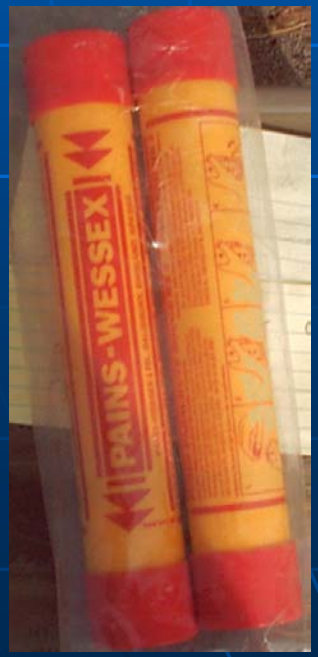
Pyrotechnics & Smokes

60mm Illuminating Cartridges

Over 360,000 processed



Signal Smokes

Signal Flares

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S&As, Primers, Detonators

Millions Processed

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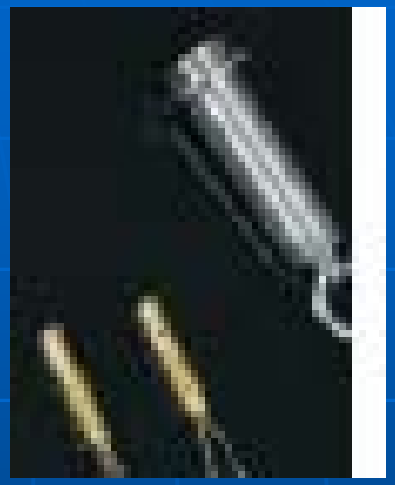
CAD/PADs



Millions Processed

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Grenades

M42 Grenades – Over 6 million processed

40 mm Practice Grenade

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Magazine Storage

- Four magazines
- 100,000 pound NEW capacity per magazine
- Comply with DoD and ATF Security Requirements
- Intrusion Alarms and CCTV
- Key Control
- Computerized Waste Tracking

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Typical Aboveground Storage Magazine

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Storage Magazine From Inside

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Waste Approval and Tracking

- Wastes profiled before accepted
  - Technical Data Package assembled
- Safe Handling Procedures developed
- Hazard Reviews of all new waste streams
- Waste tracked by profile number, manifest number, and/ or ALN number
- Computerized Waste Tracking System
  - DCS control
  - Burn reports
- Tracking of scrap

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Fingerprinting

- Inspection of truck and manifest
- Waste sample selection
- Inspection of waste
- Compare waste to information in Technical Data Package
- Label and enter waste into Waste Tracking System

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Direct Feed or Preprocessing

- Waste is transported to Feed Room or Storage Feed Handling Building
- SFHB is used for repackaging or demil
  - Can go back to Magazine or to Feed Room
- All waste is scanned into Waste Tracking System for each movement

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EBVEEC Permits

- RCRA Part B Permit (expires 2012)
- Title V Air Permit (expires 2006)
- NPDES Permit (expires 2010)
  - Storm Water / Sanitary – no process discharge
- ATF License (expires 2006)
- DOT Hazardous Material License (expires 2006)
- FAA Stack Permit

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What Can EBV EEC Do For You?

In addition to demil and disposal of your explosive wastes, EBV EEC can assist with:

- Ensuring packaging and transportation comply with DOT requirements
- Arranging Transportation
- Printing Manifest, LDR Form, HW Labels
- Analysis & Characterization of HW
- Completing and printing WCPs

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Who Do I Contact To Find Out More?

For a free cost estimate for demil / disposal of your explosive wastes, contact:

Eastern Sales Office

Dave Zoghby – 610-298-3085

Western Sales Office

Mark Zaugg – 801-295-2003

Joplin Facility

417-624-0212 Ext 409

Website: www.ebveec.com

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Summary

EBV EEC's Joplin, MO, TSDF

- 10 year history in disposal of explosive waste - >25M lbs destroyed
- Only commercial HW incinerator in US specifically designed for explosive materials and devices
- Largest commercial disposer of explosive waste in the US
- Compliant with all state and federal SHE and Security Regulations
- Available for disposal of your explosive wastes

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"EBV EEC" Also Means: Environmentally Best Value for disposal of Explosives and Energetic Components

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